

HYDRAULICS OF RIVER FLOW

UNDER ARCH BRIDGES

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JUNE 1964

NO. II

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Highway  
Research  
Project

PURDUE UNIVERSITY  
LAFAYETTE INDIANA

by  
J.W.DELLEUR



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Vol. II

by

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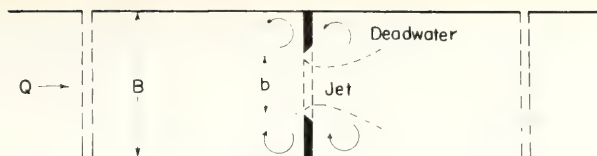
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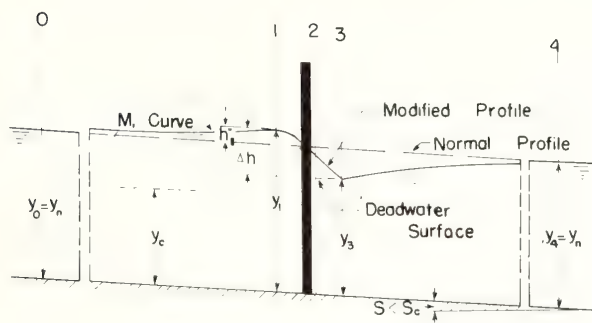
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A.) PLAN



B.) MILD SLOPE CHANNEL

C.) WEIR PLATES

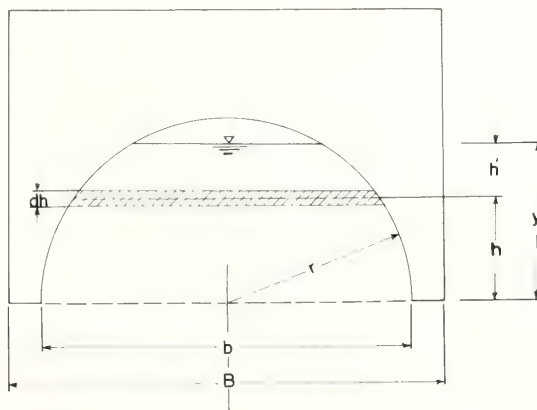
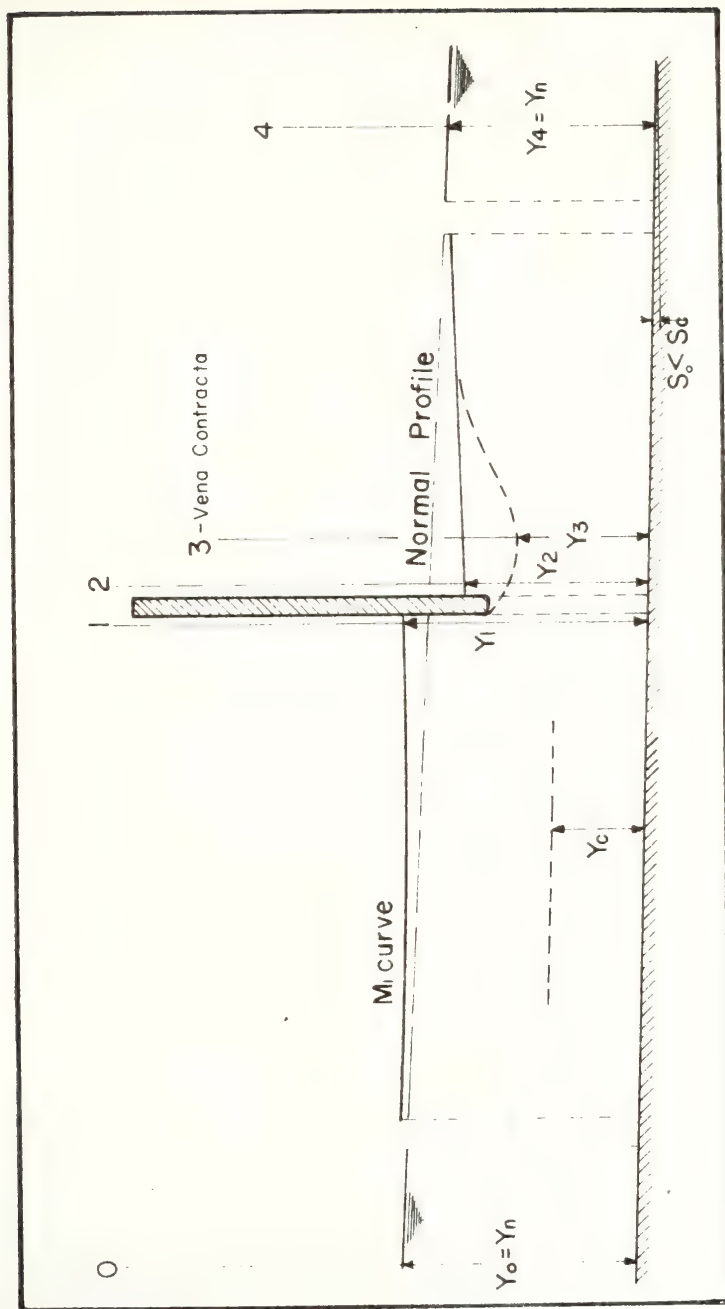


FIGURE 3-1 DEFINITION SKETCH







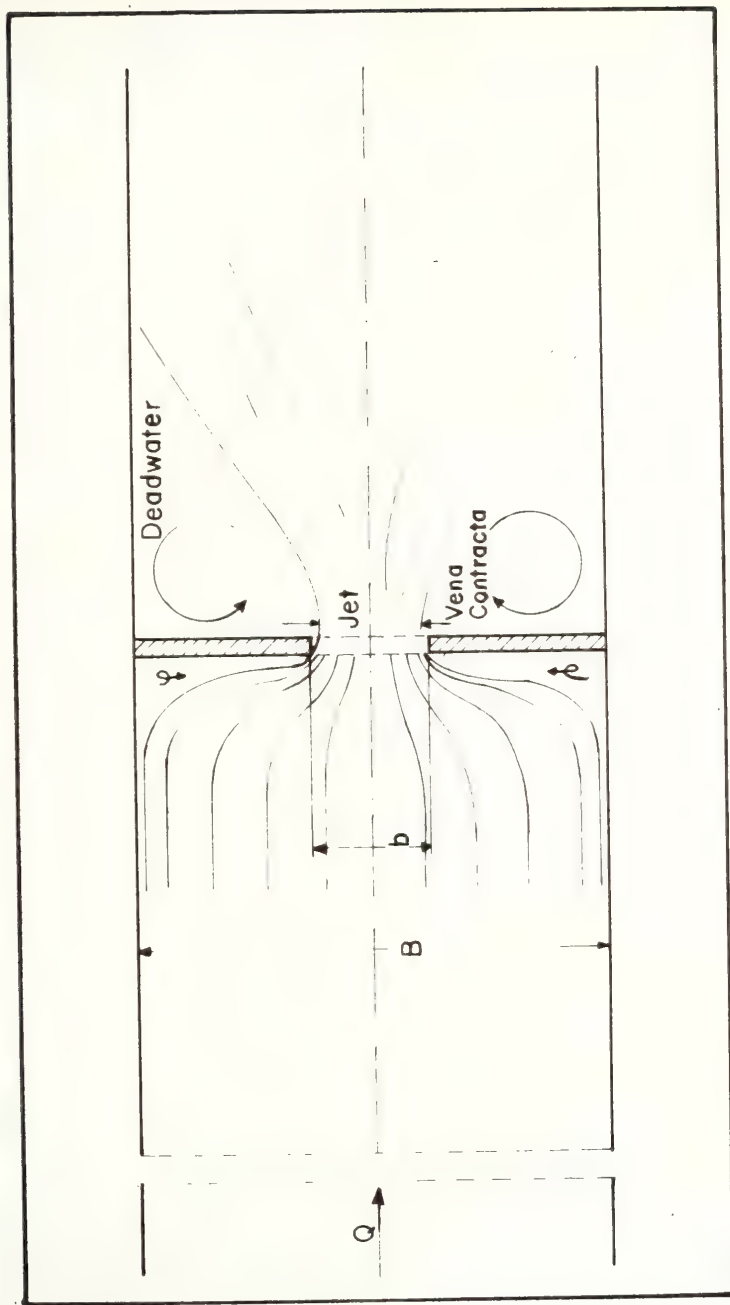


Fig 3-3 Plan View of Flow Through a Submerged Constriction





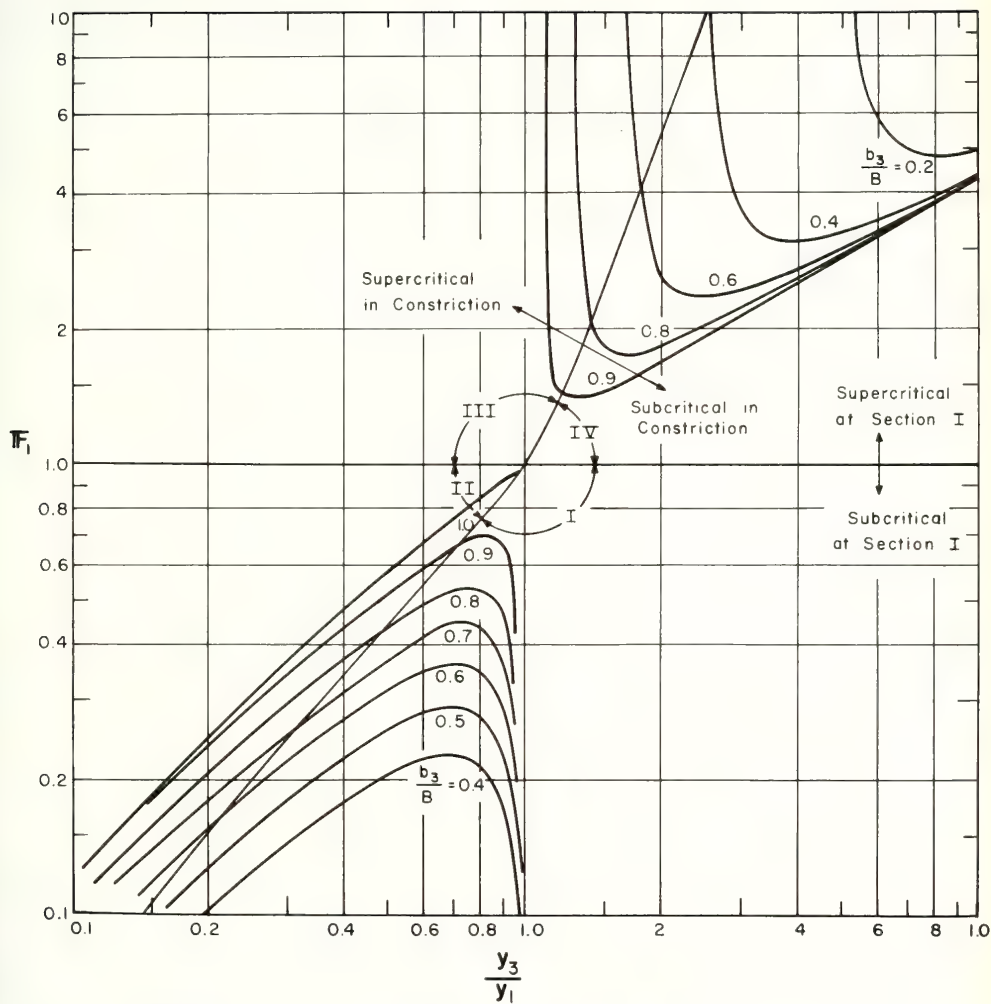


FIGURE 3-4 — CLASSES OF FLOW IN SUDDEN CONTRACTIONS IN OPEN CHANNELS



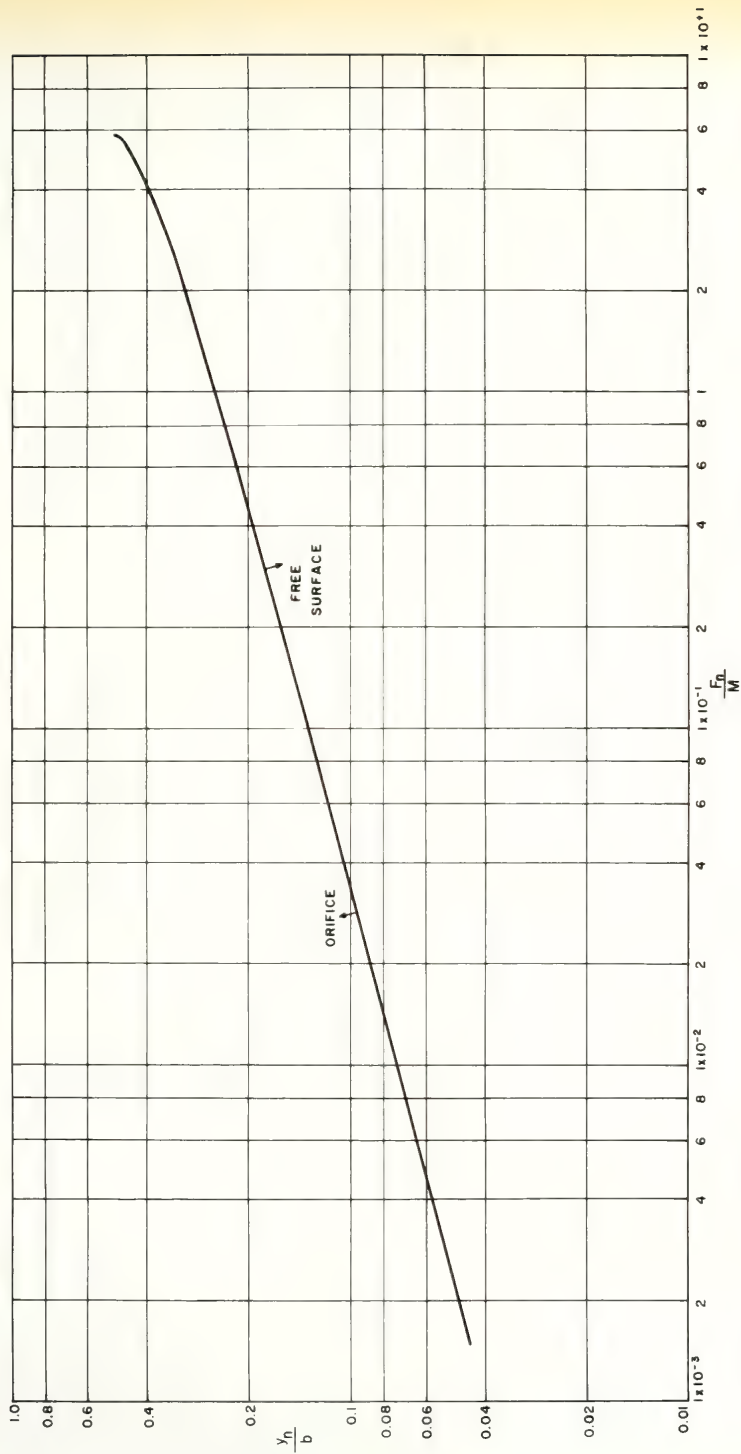


FIGURE 3-5 -- EMPIRICAL RELATIONSHIP TO DISTINGUISH BETWEEN FREE SURFACE FLOW AND ORIFICE FLOW



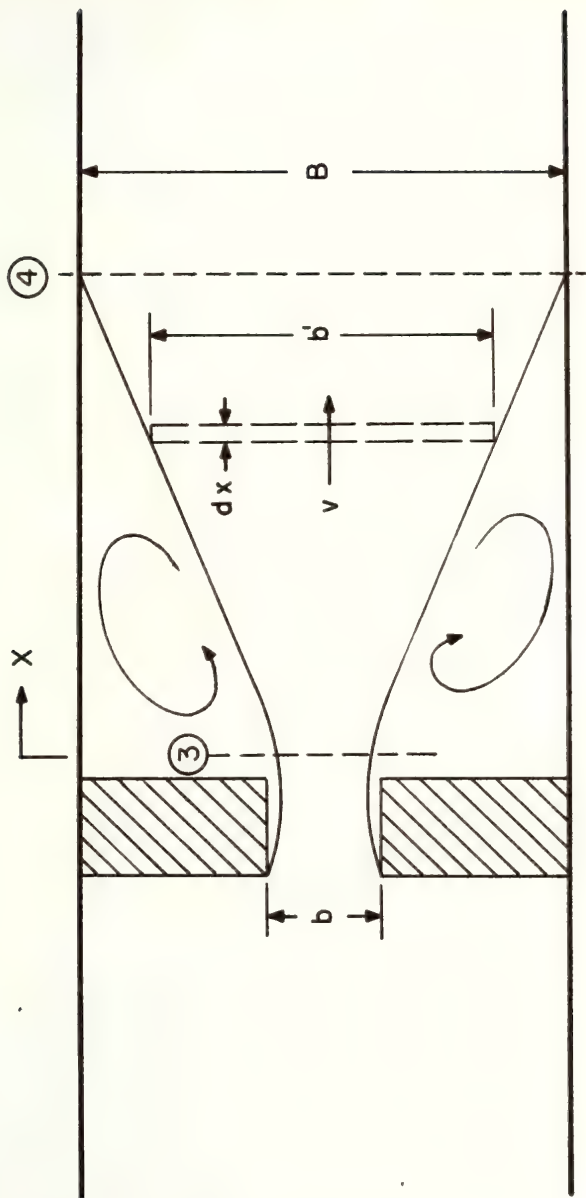


FIGURE 3-6 — DEFINITION SKETCH FOR ANALYSIS OF EXPANDING FLOW





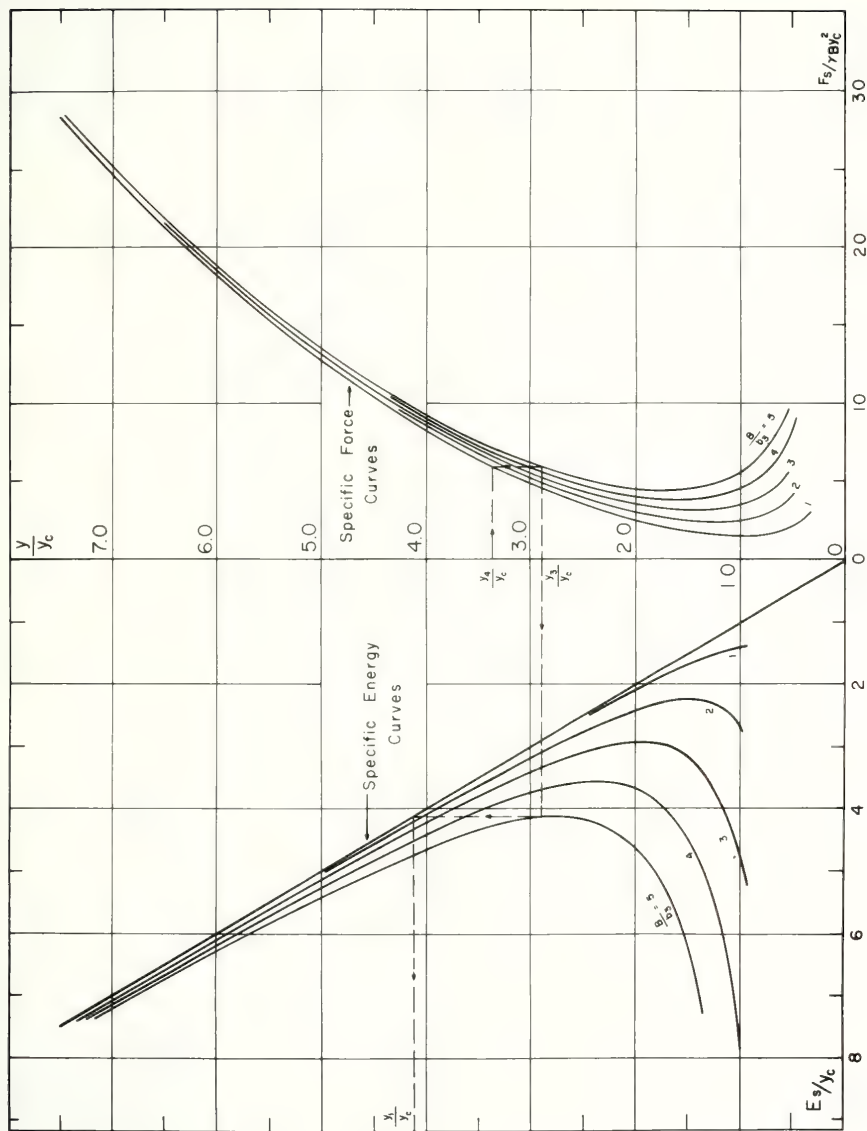


FIGURE 3-7 — GRAPHICAL SOLUTION OF BACKWATER DUE TO A CONSTRICTION



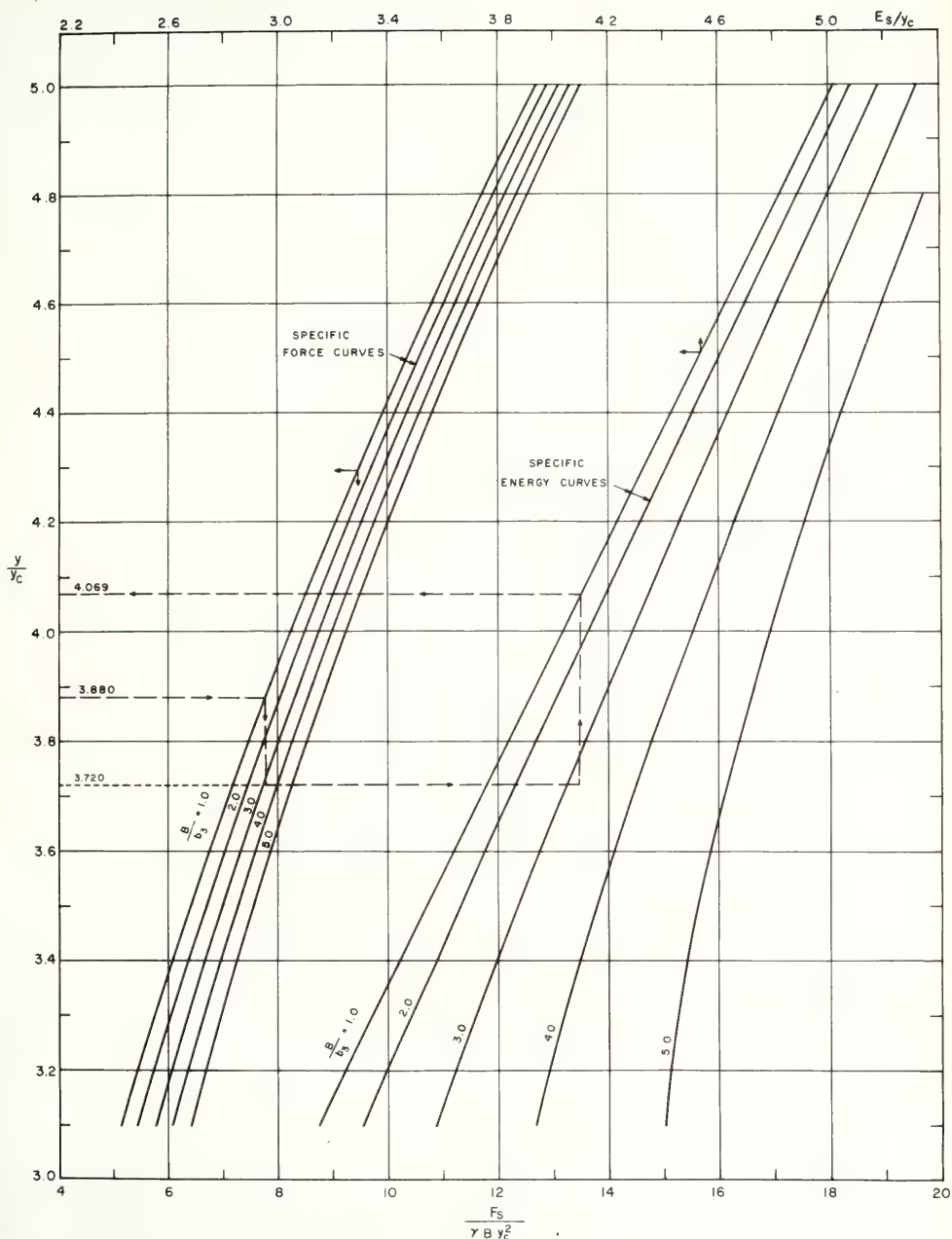


FIGURE 3-8 — DETAIL OF GRAPHICAL SOLUTION OF BACKWATER DUE TO A CONSTRICTION



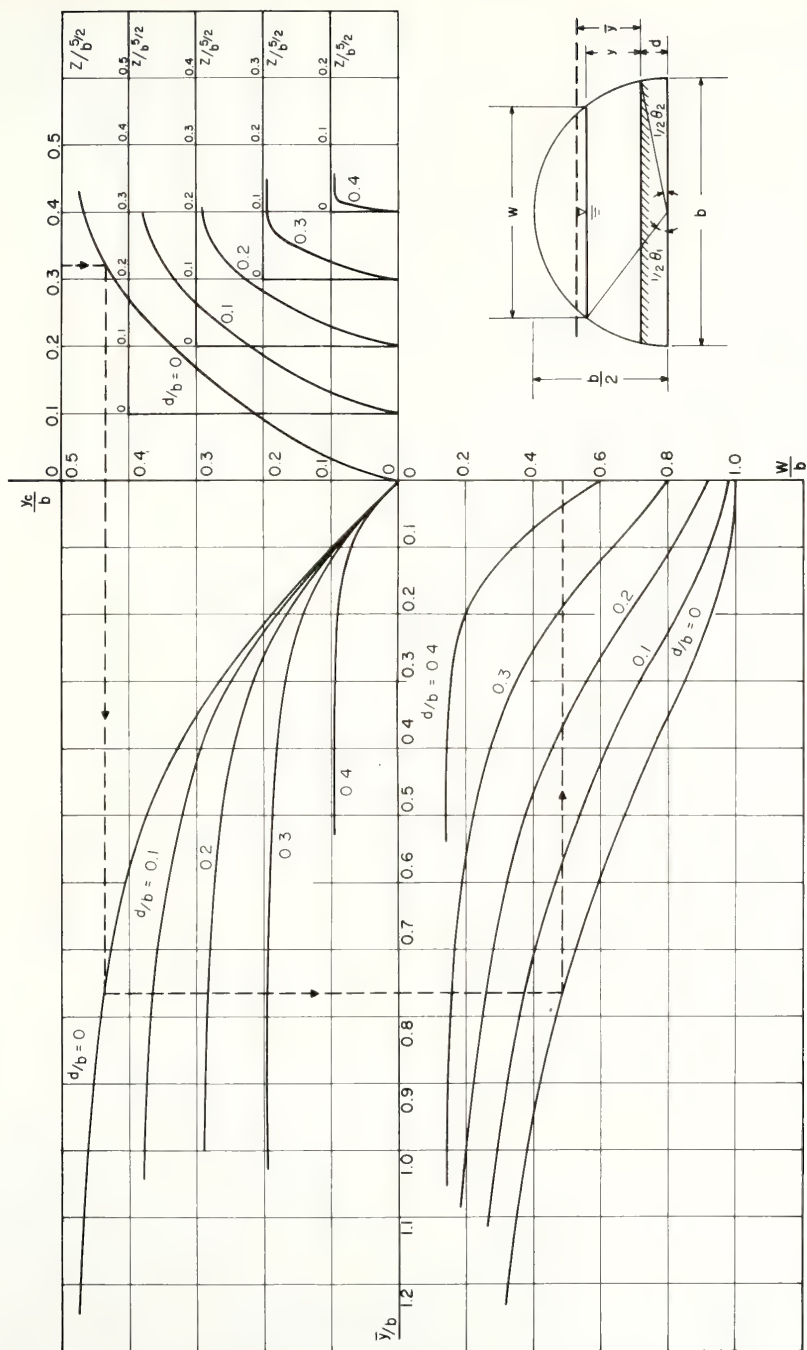


FIGURE 3-9 — GEOMETRIC PROPERTIES OF SEMI-CIRCULAR AND CIRCULAR SEGMENT ARCHES





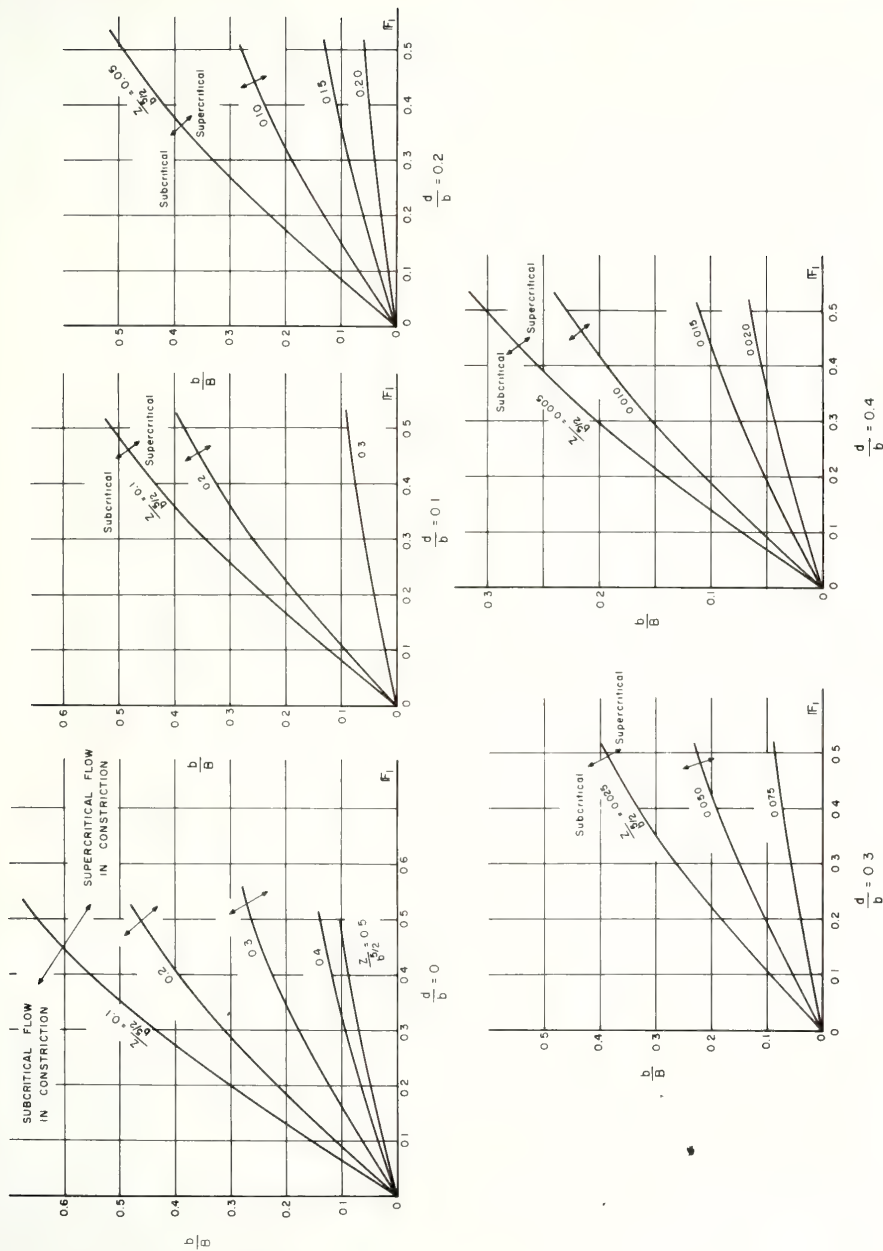


FIGURE 3-10 - LIMITING BACKWATER - BOUNDARY BETWEEN FLOWS OF CLASSES I & II  
SEMI - CIRCULAR AND CIRCULAR SEGMENT ARCHES



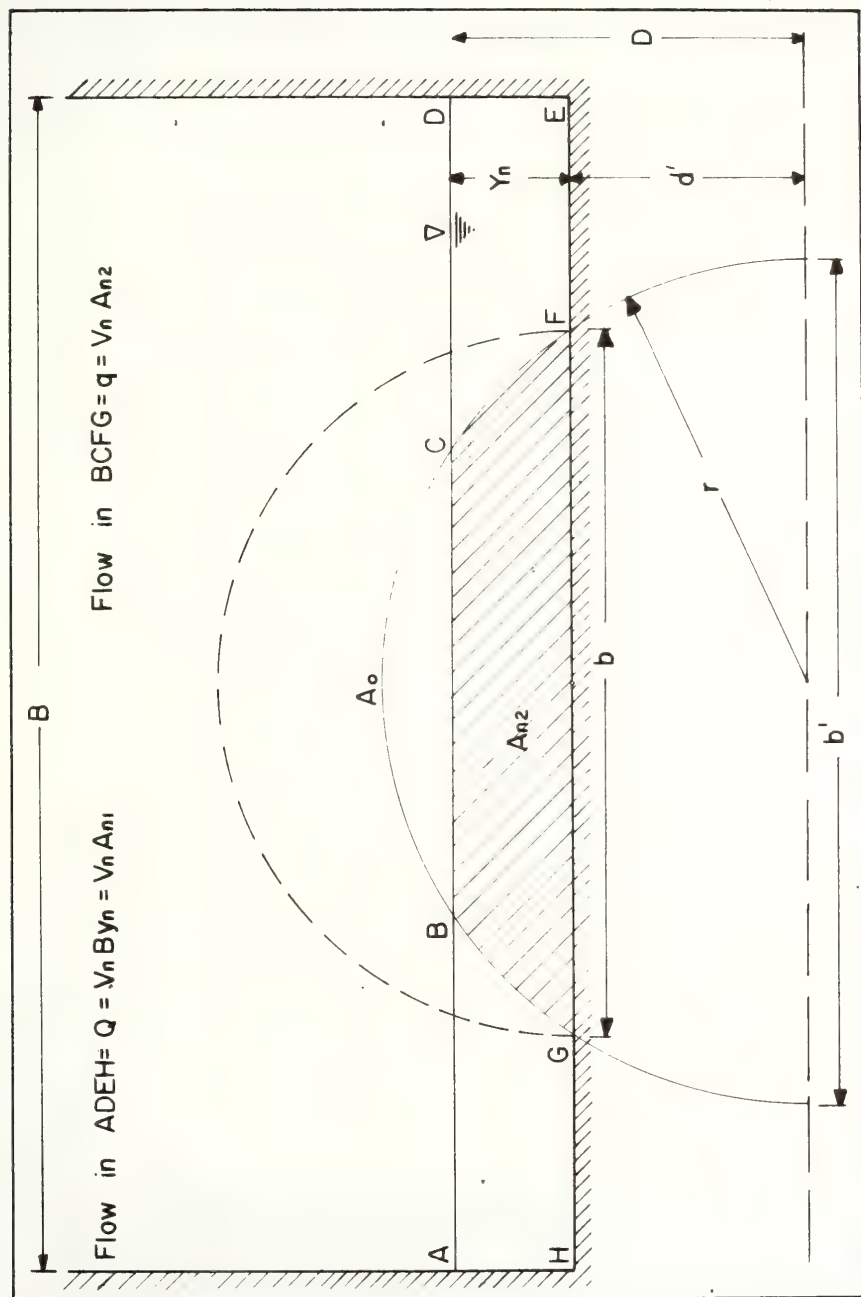


Fig 3.11 Definition Sketch for the Channel Opening Ratio



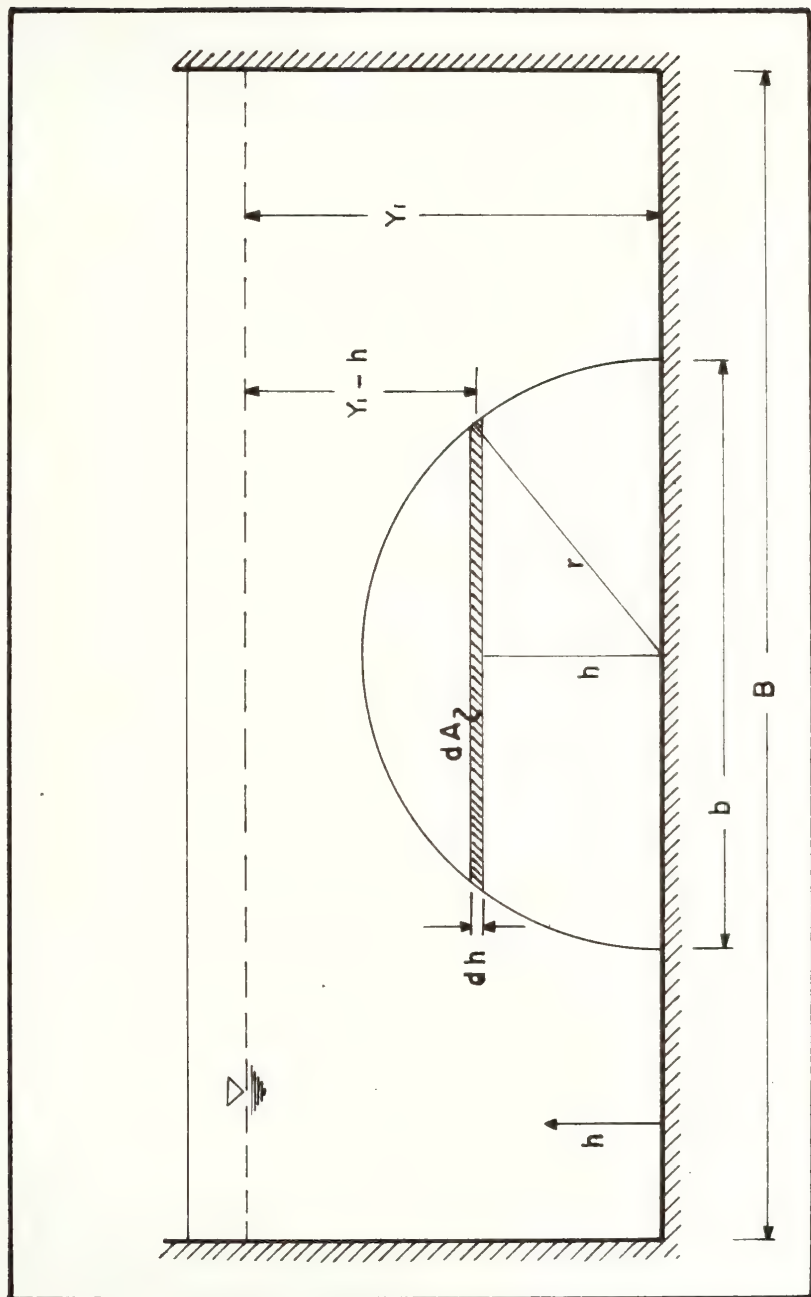
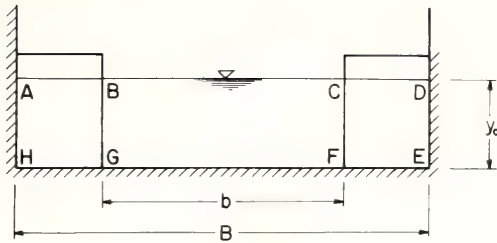


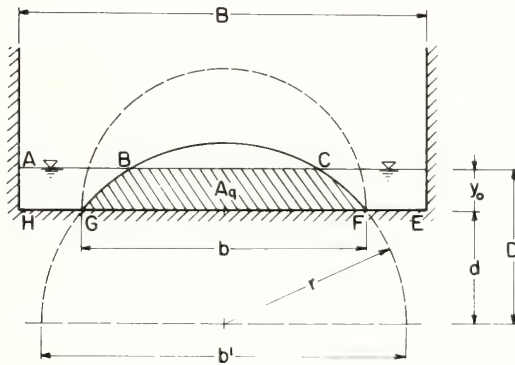
FIG 3-11a DEFINITION SKETCH FOR ORIFICE FLOW CALCULATION





FLOW IN ADEH =  $Q = V_0 B y_0$

FLOW IN BCFG =  $q = V_0 b y_0$



FLOW IN ADEH =  $Q = V_0 B y_0$

FLOW IN BCFG =  $q = V_0 b y_0$

DEFINITION SKETCH FOR THE DEVELOPMENT OF  
THE CONTRACTION RATIO

Figure 3-12





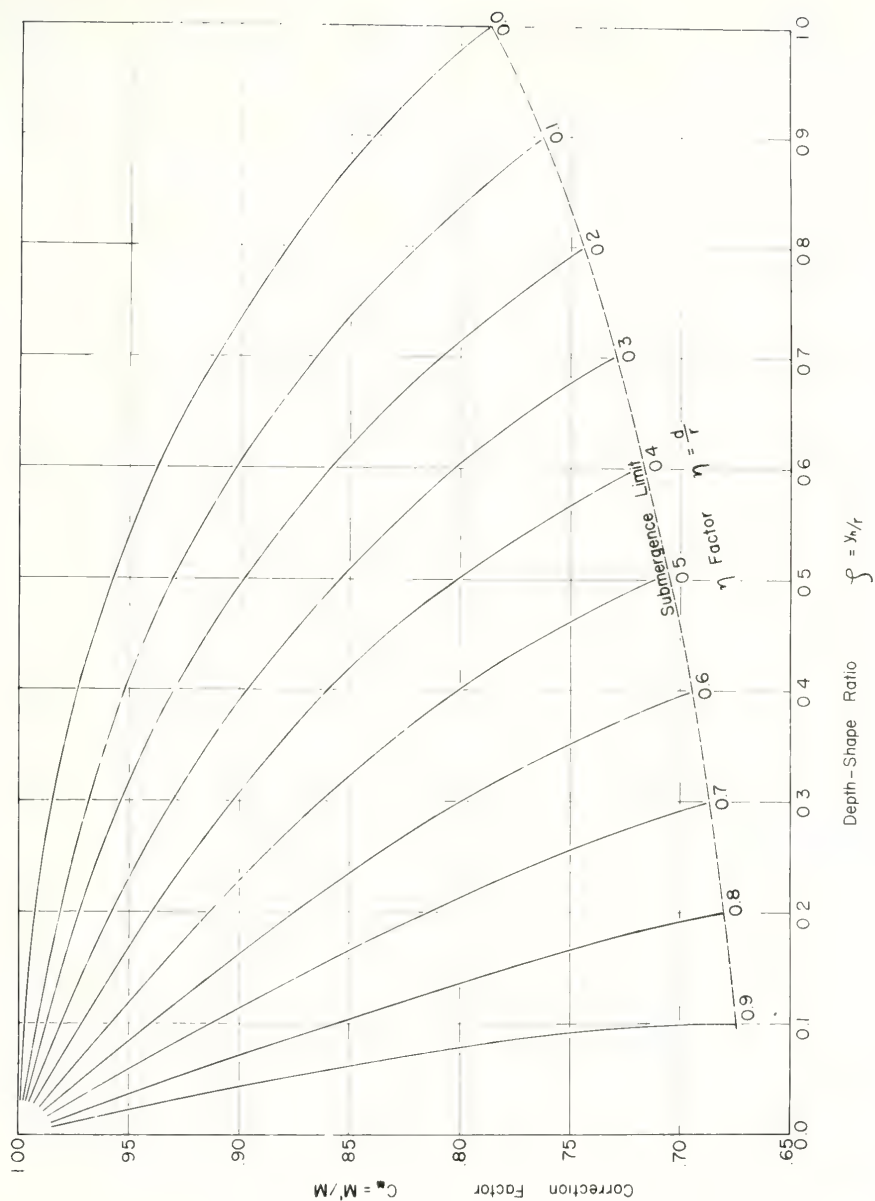


FIGURE 3-13 CORRECTION COEFFICIENT FOR THE CHANNEL OPENING RATIO



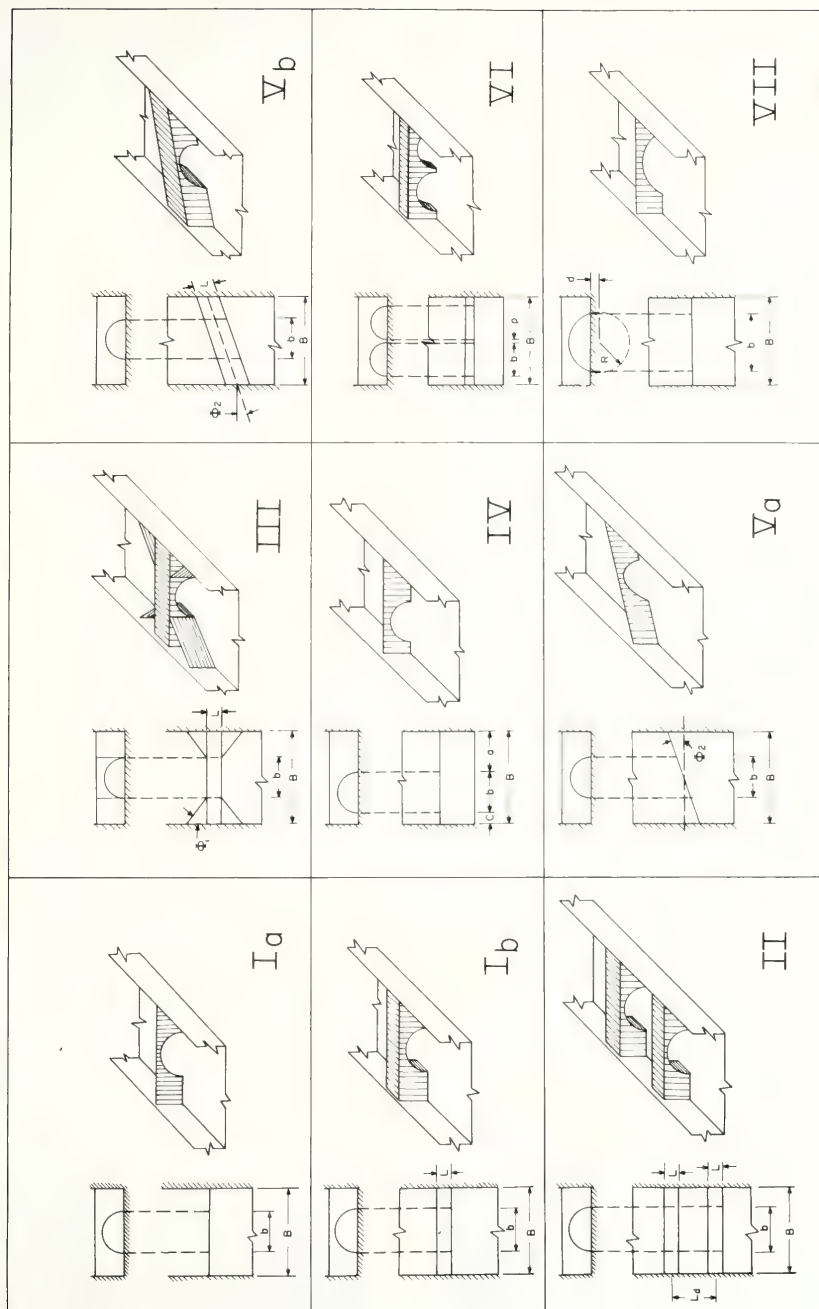


FIGURE 3-14 DEFINITION SKETCHES OF TEST GEOMETRIES



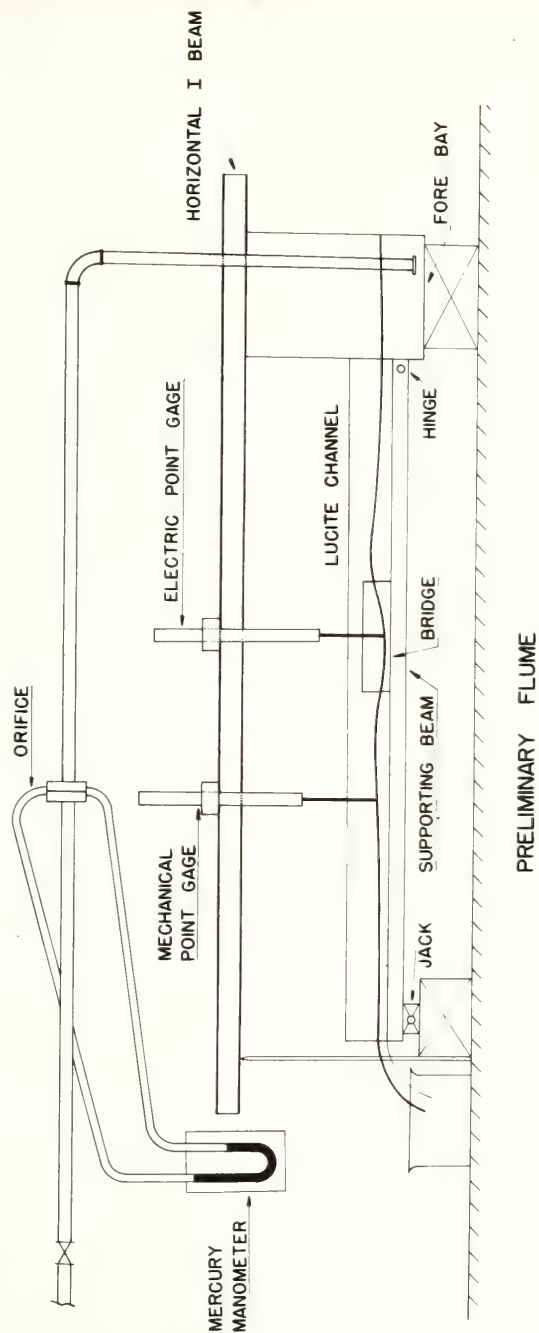
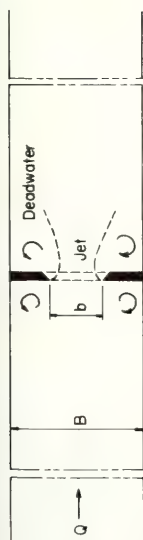


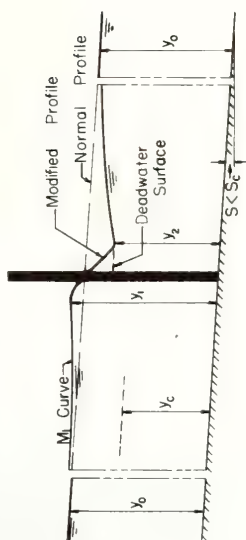
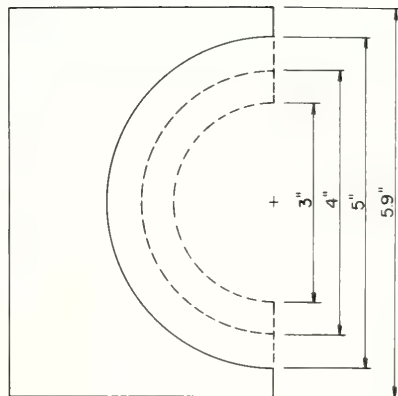
FIG. 4 - 1



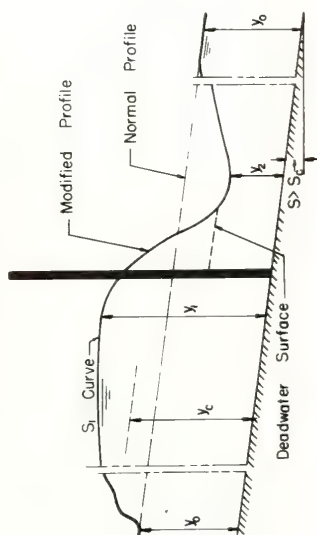


A) PLAN

D) WEIR PLATES



B) MILD SLOPE CHANNEL



C) STEEP SLOPE CHANNEL

EFFECT OF CHANNEL CONSTRICTION  
ON WATER SURFACE PROFILE

FIG. 4-2





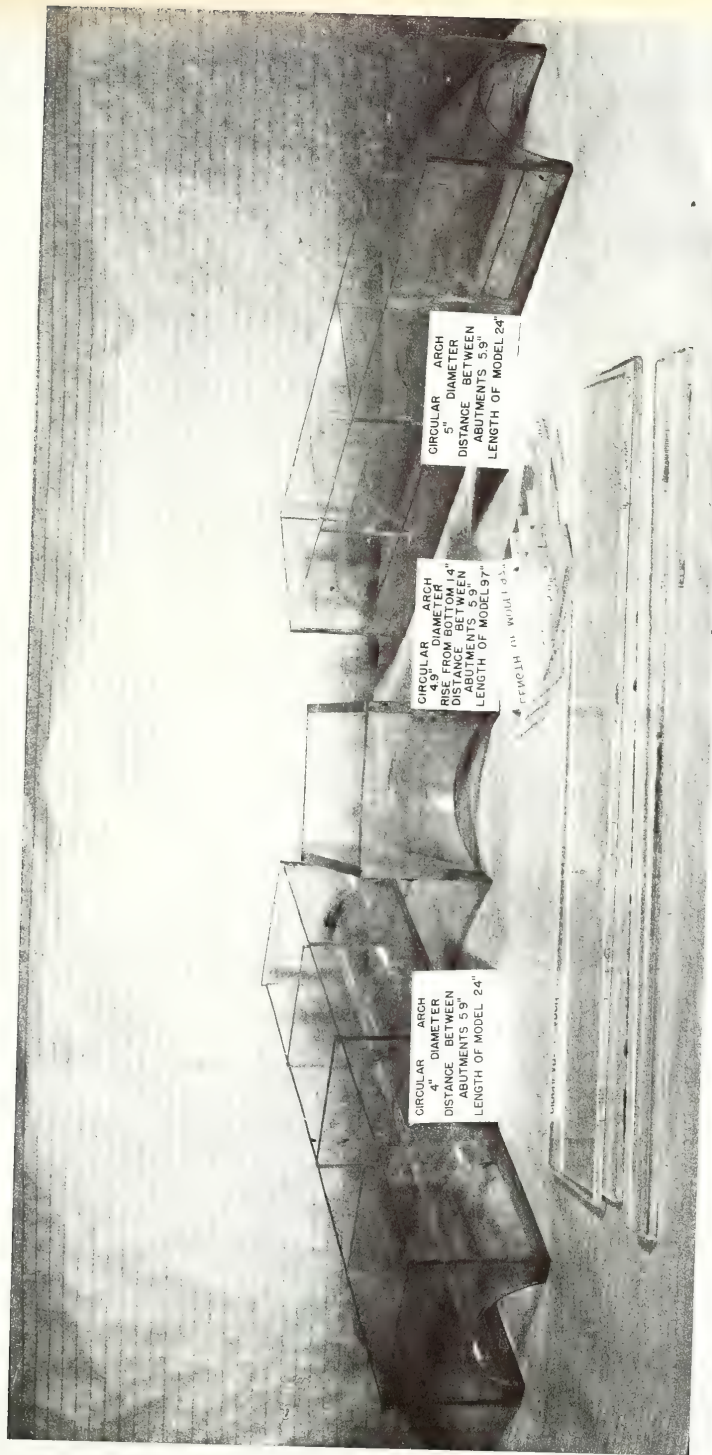


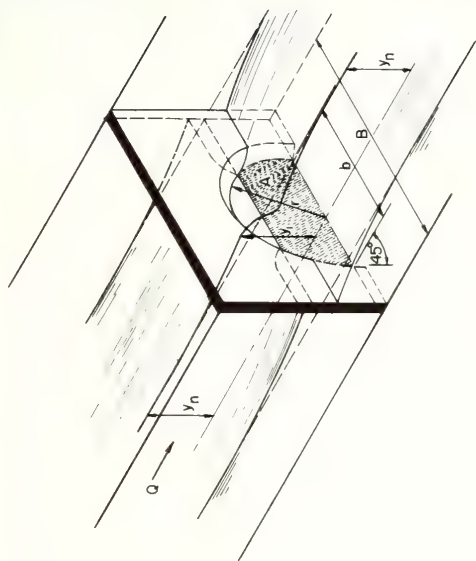
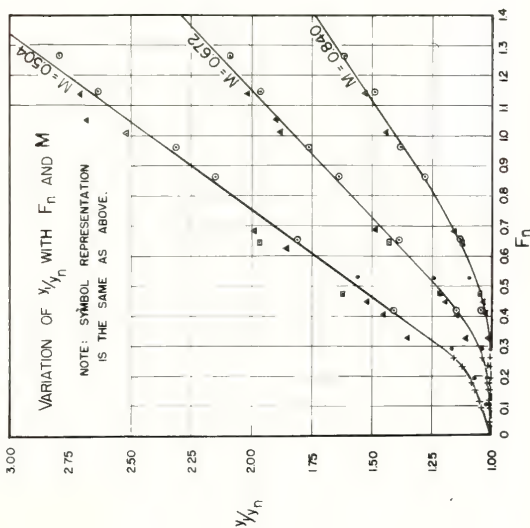
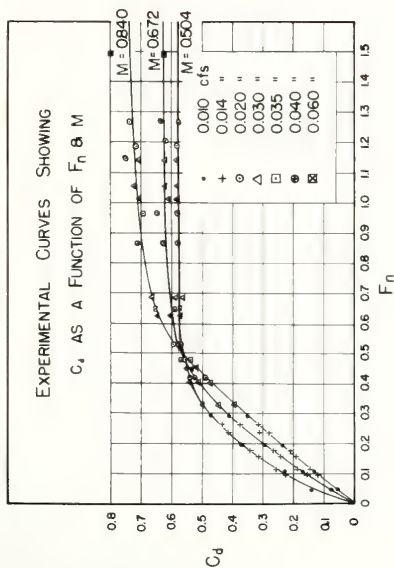
FIGURE 4-3 THREE DIMENSIONAL MODELS FOR PRELIMINARY STUDIES





FIGURE 4-4 SMALL FLUME WITH ARTIFICIAL ROUGHNESS INSTALLED, and MECHANICAL AND ELECTRICAL GAGES





$$Q = C y_1^{3/2} b T \quad (1)$$

$$C = c_d \sqrt{2g} \quad 17/24$$

$$T = \left[ -0.0294 \left( \frac{y_1}{r} \right)^2 - 0.00177 \left( \frac{y_1}{r} \right)^4 + \dots \right]$$

$$y_1/y_n = \left( F_n \sqrt{g} / C_M A \right)^{2/3} \quad (2)$$

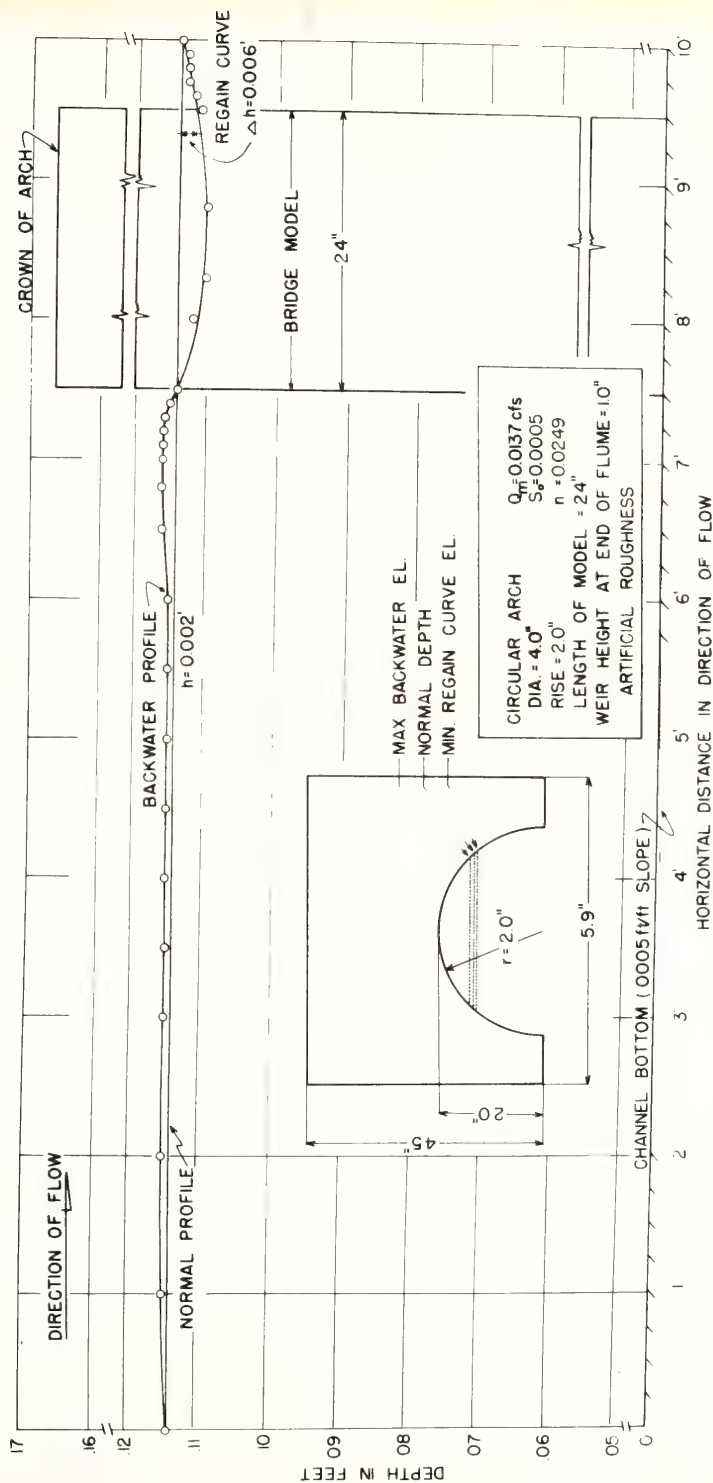
$$F_n = V_n / \sqrt{g y_n}$$

$$M = b/B$$

SEMICIRCULAR WEIR TESTS

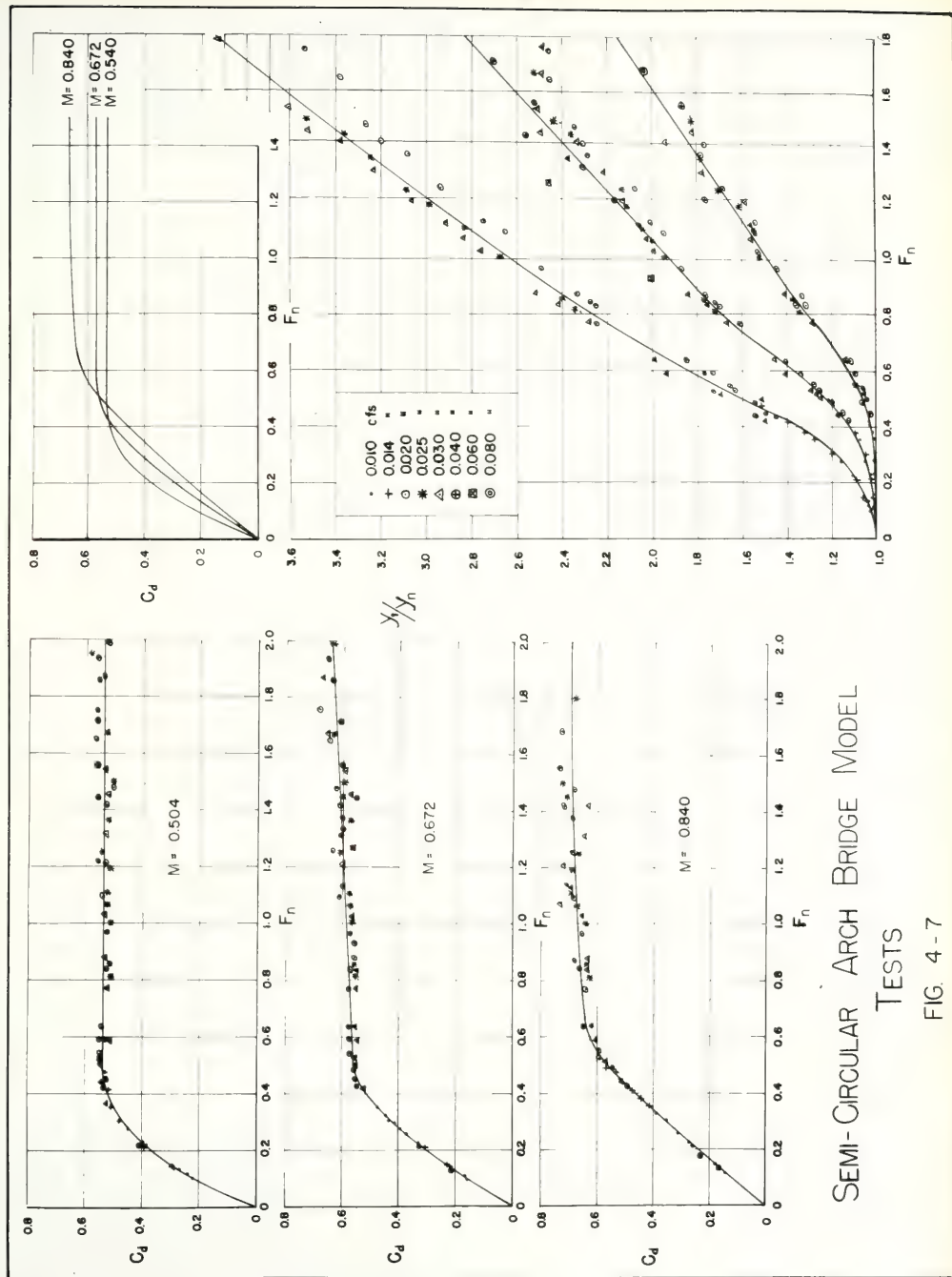
FIG. 4-5



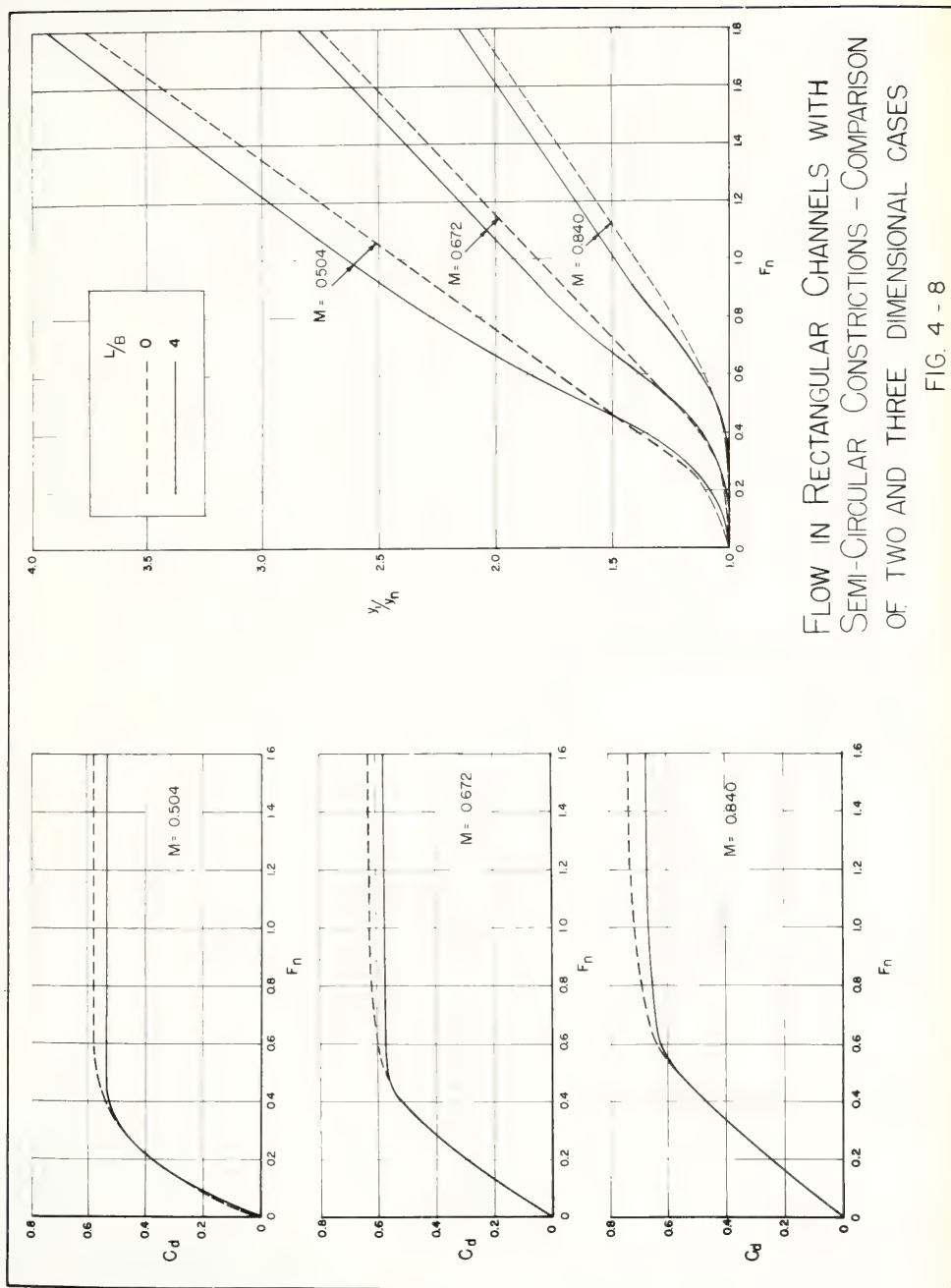












FLOW IN RECTANGULAR CHANNELS WITH  
SEMI-CIRCULAR CONSTRICTIONS - COMPARISON  
OF TWO AND THREE DIMENSIONAL CASES

FIG. 4 - 8



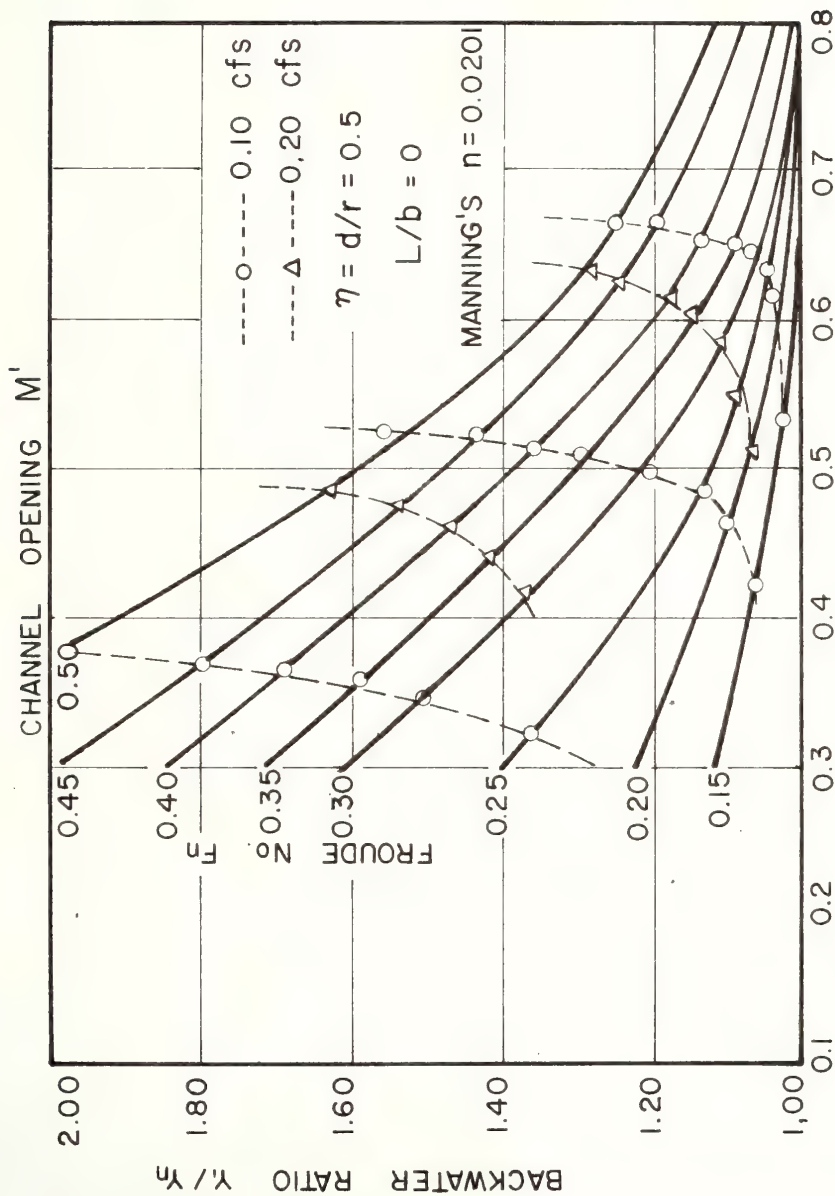


FIG 4-8a VARIATION OF THE BACKWATER RATIO FOR SEGMENT ARCHES - SMALL FLUME - ROUGH BOUNDARIES



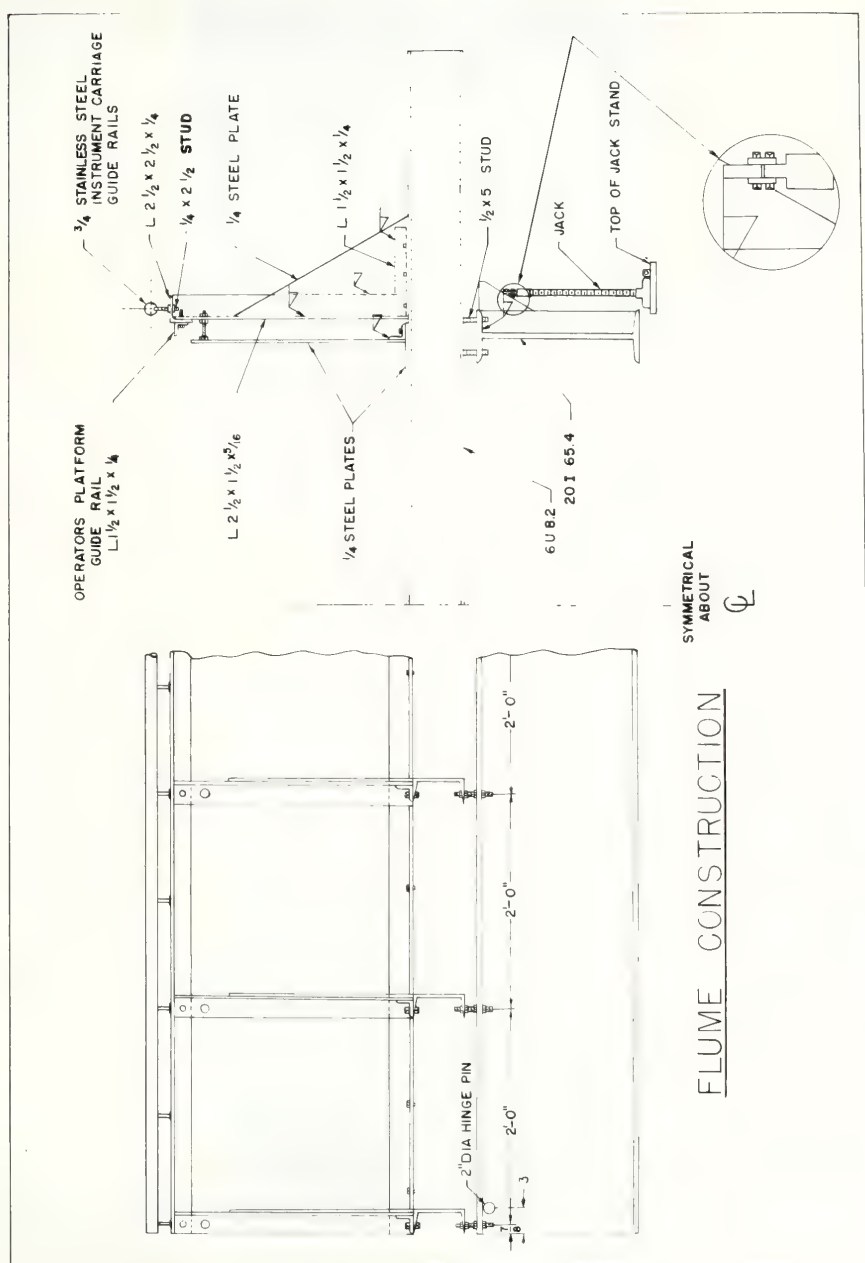


FIGURE 5-1





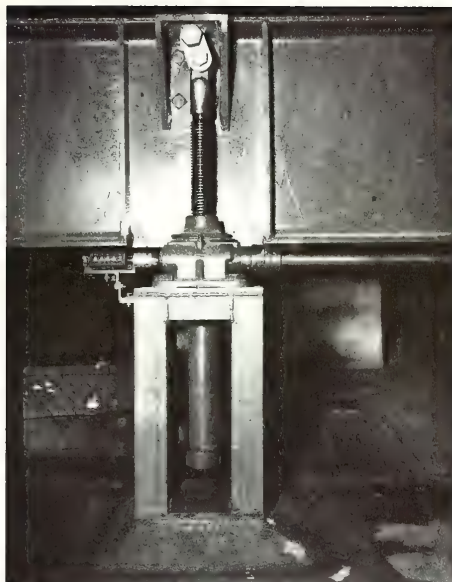


FIG 5-2 JACK DETAIL



FIG 5-3 TAIL GATE



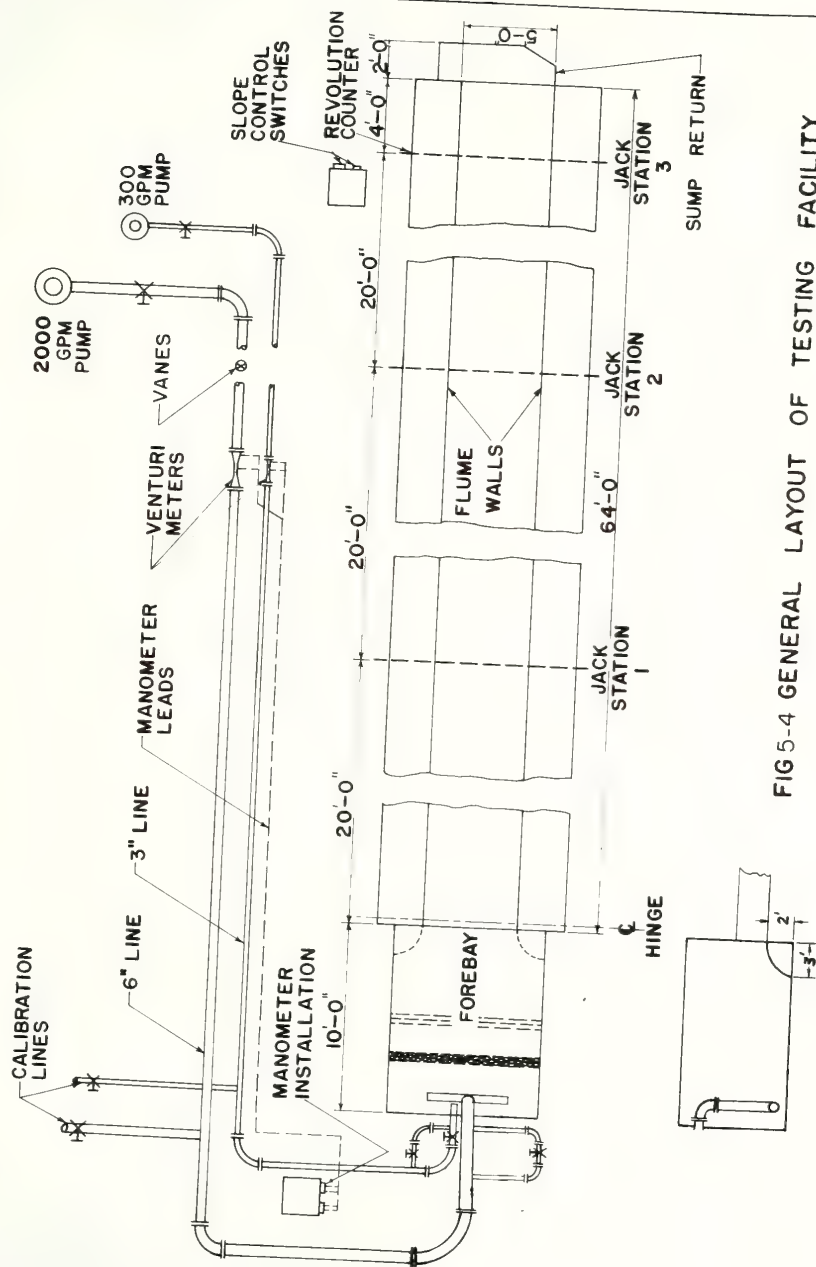


FIG 5-4 GENERAL LAYOUT OF TESTING FACILITY



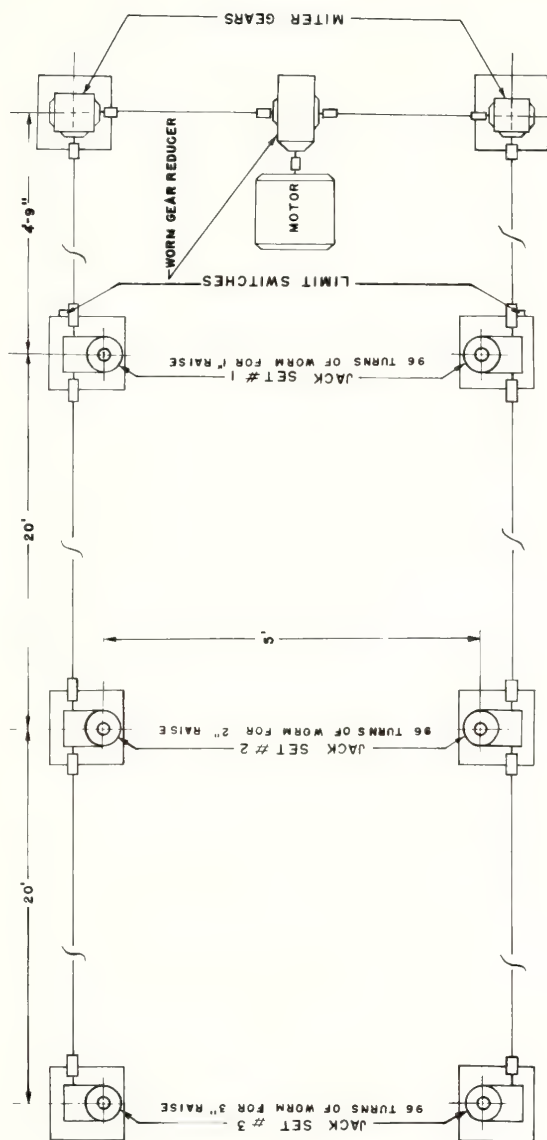


FIG 5-5 PLAN VIEW OF JACKS AND GEARS



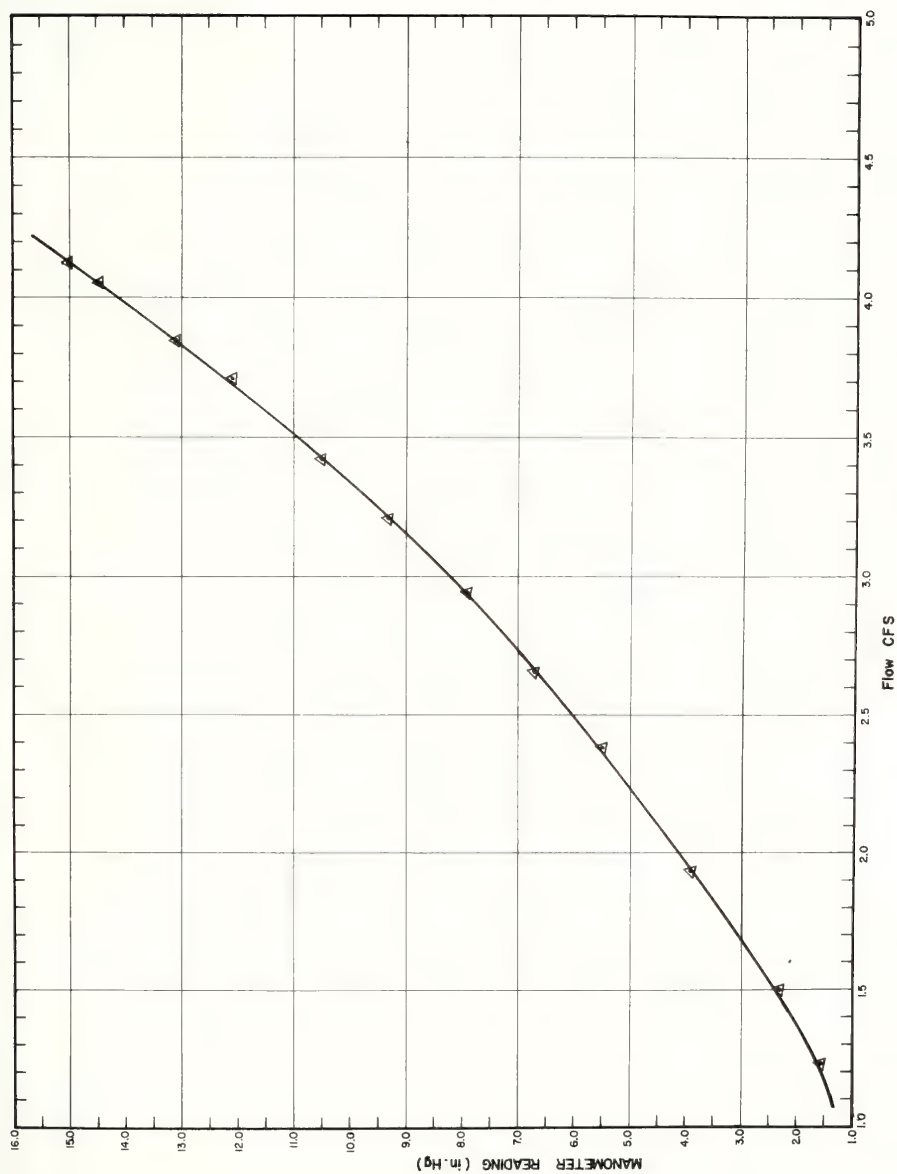
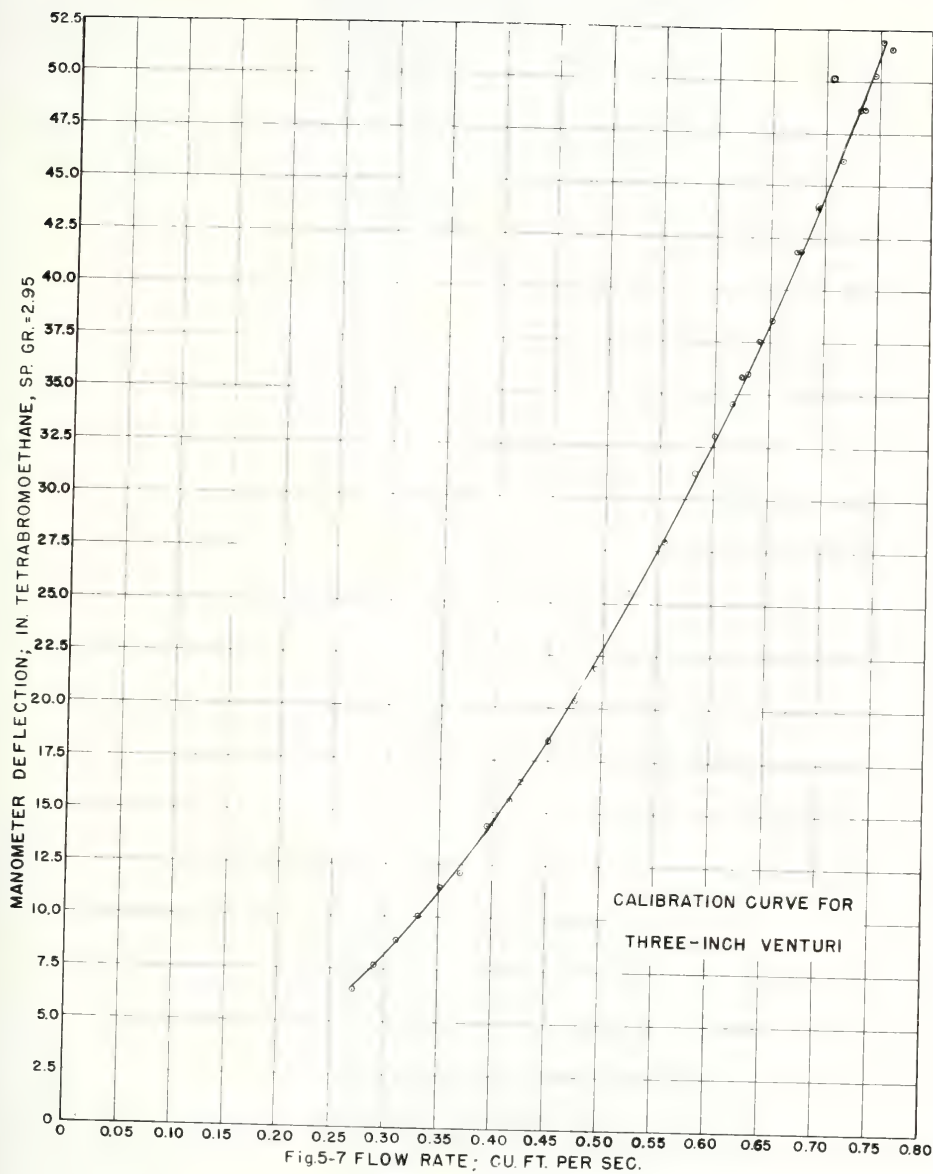


FIG. 5-6 CALIBRATION CURVE FOR 6" VENTURIMETER









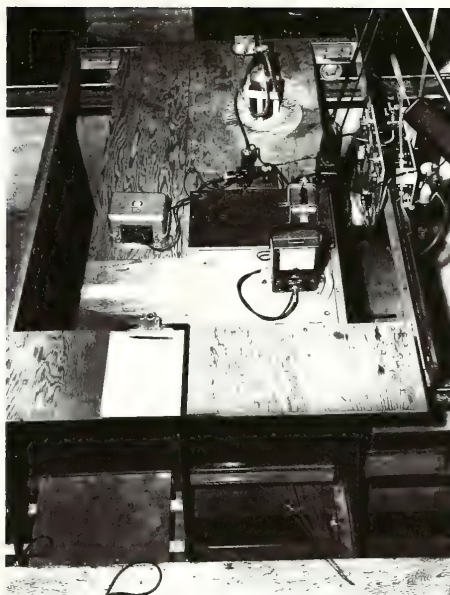


FIG 5-8 TOP VIEW OF INSTRUMENT CARRIAGE

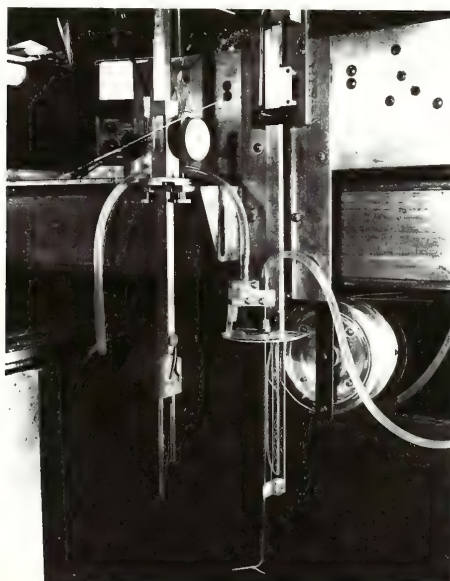


FIG 5-9 POINT GAGE AND PRANDTL TUBE



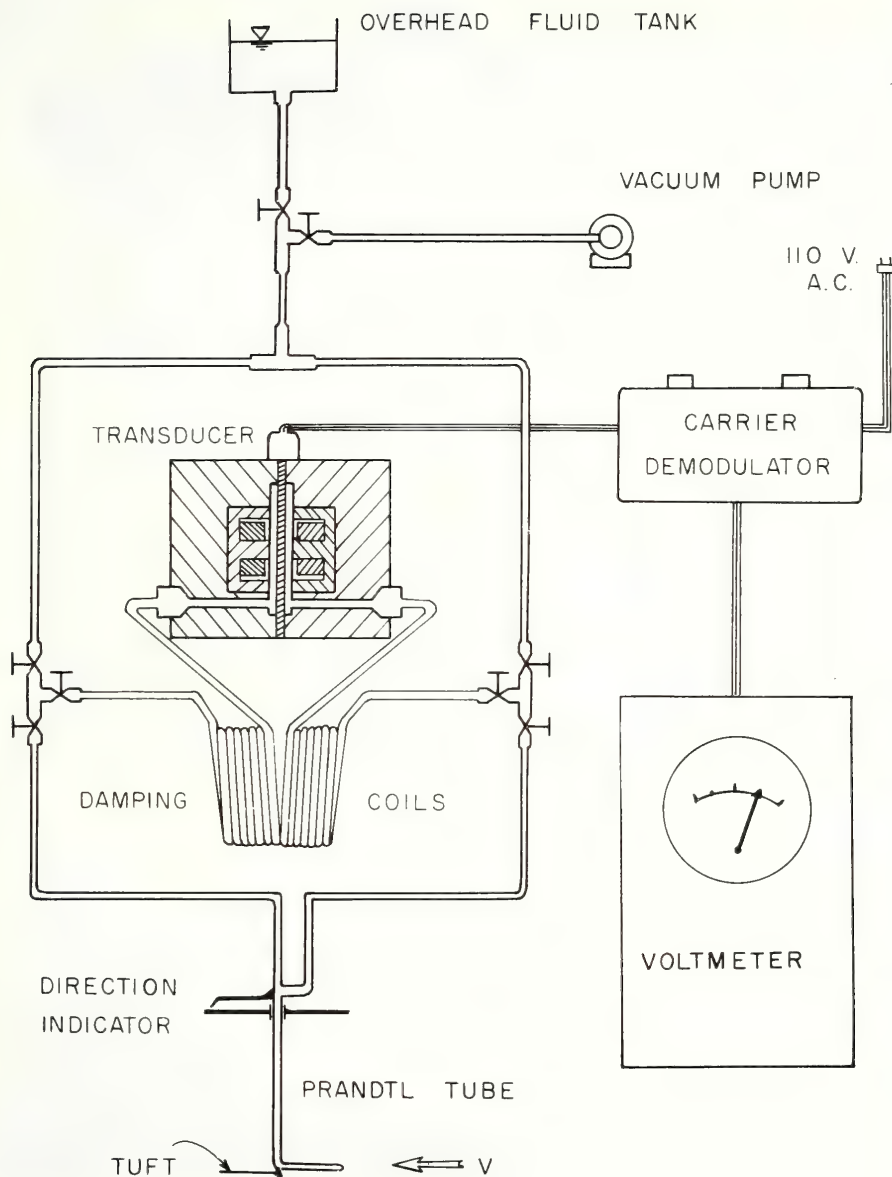


FIGURE 5-10 VELOCITY TRANSDUCER SYSTEM



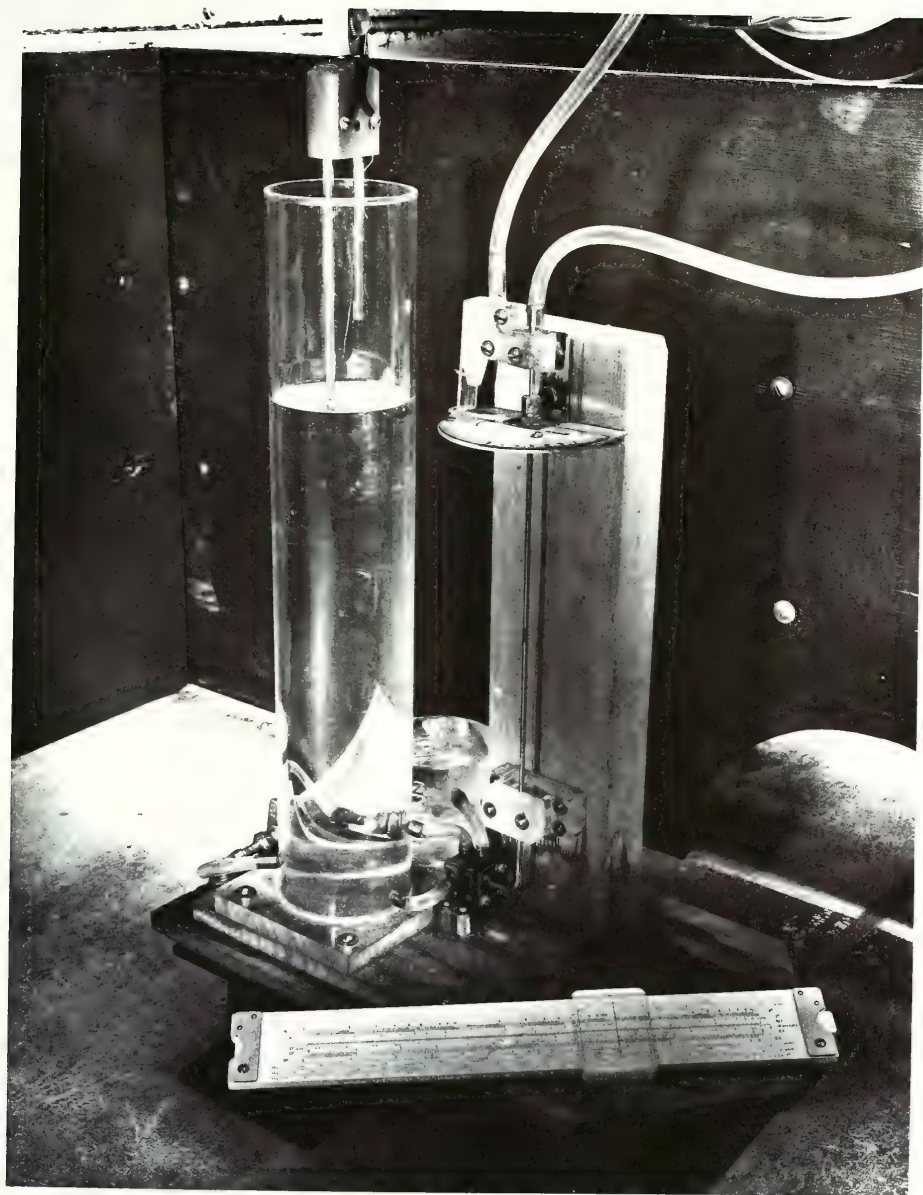


FIG 5-II CALIBRATION APPARATUS FOR VELOCITY  
TRANSDUCER SYSTEM





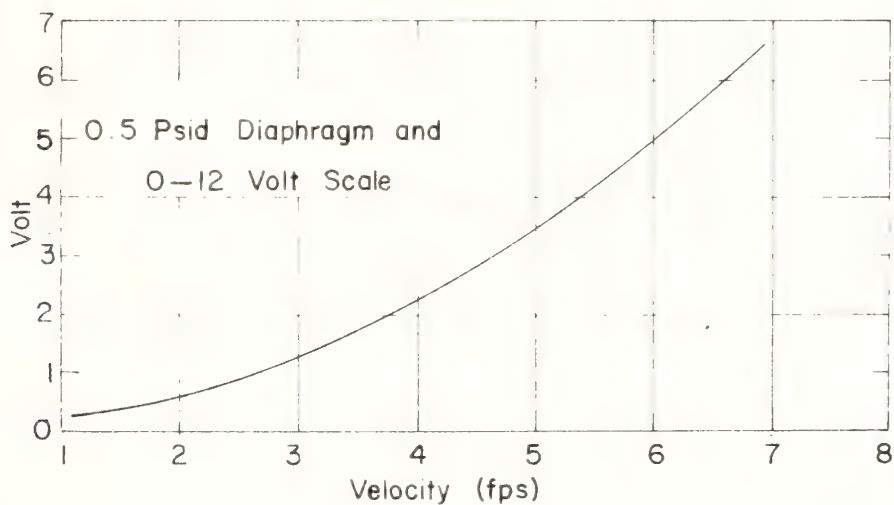
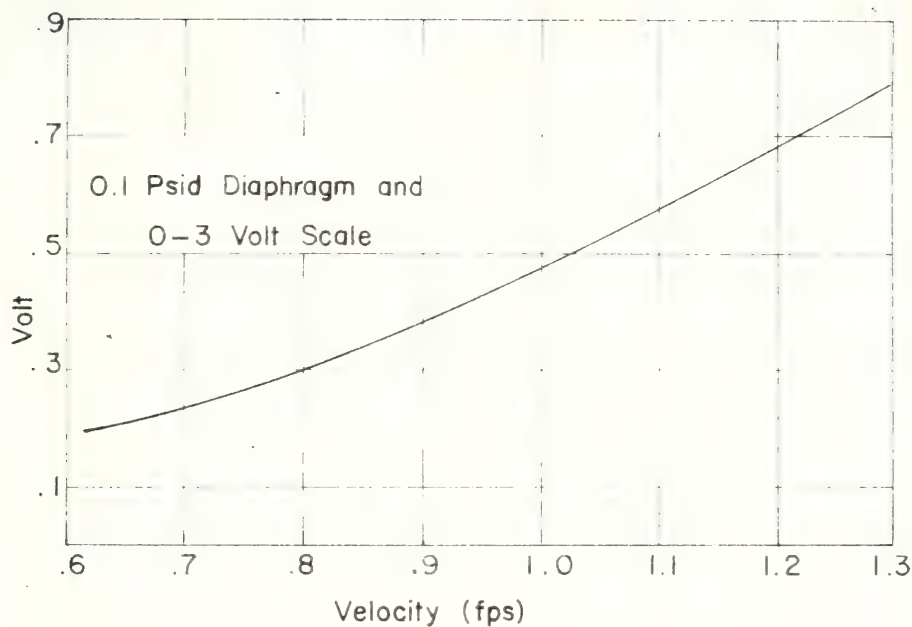


Fig.5-12 Typical Calibration Curves for Probe









FIGURE 5-14 TESTING FLUME WITH ARTIFICIAL ROUGHNESS.



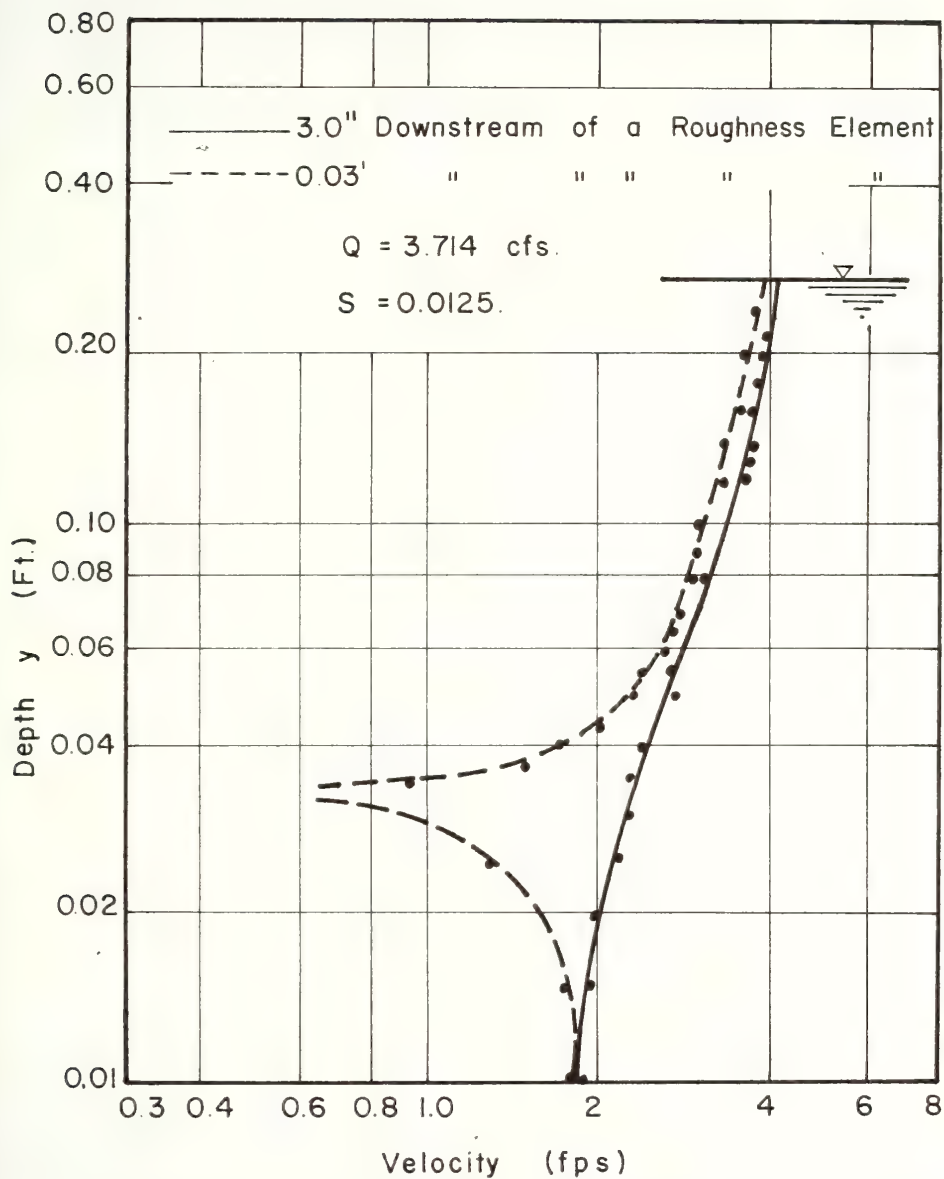


FIG 5-15 EFFECT OF BARS ON VELOCITY





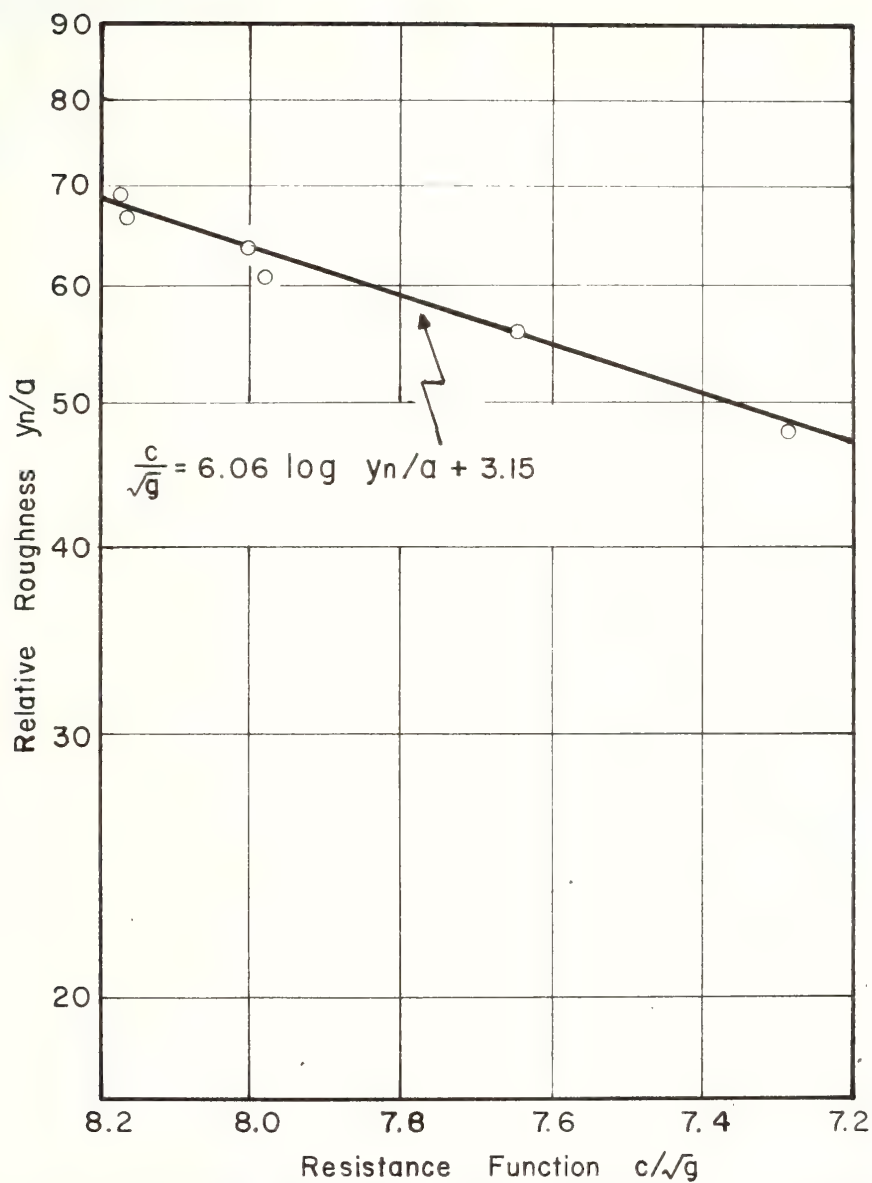


FIG 5-16 VARIATION OF RESISTANCE FUNCTION  
WITH RELATIVE ROUGHNESS  $y_n/a$



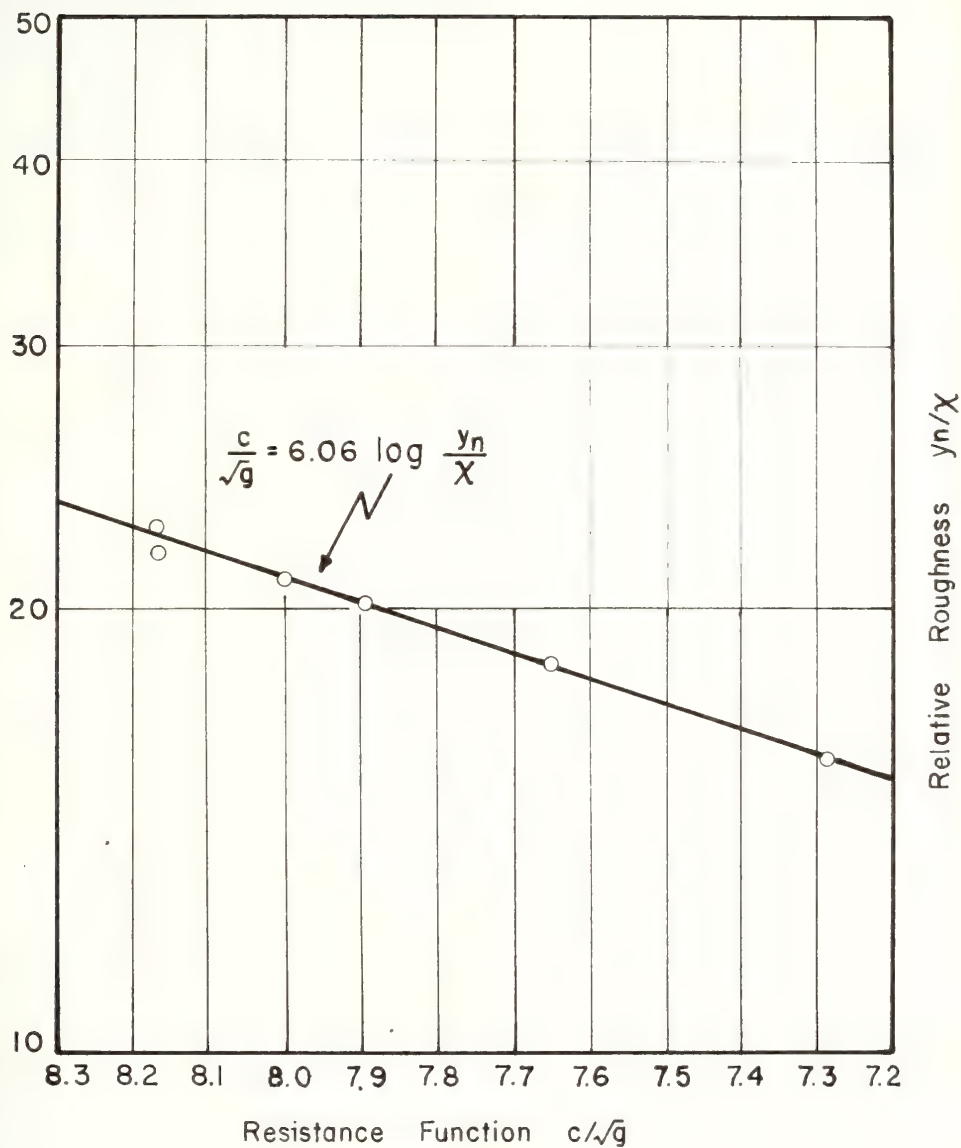


FIG 5-17 VARIATION OF RESISTANCE FUNCTION  
WITH RELATIVE ROUGHNESS  $y_n/X$



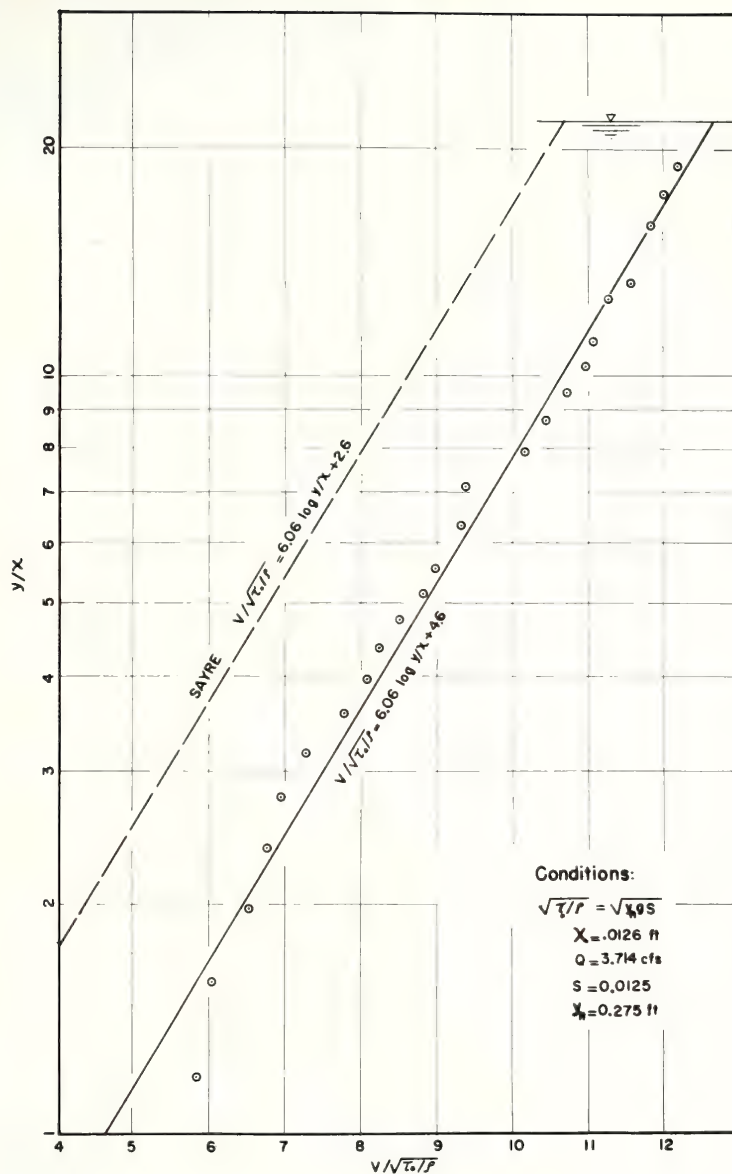


FIGURE 5-18 DIMENSIONLESS VELOCITY PROFILE



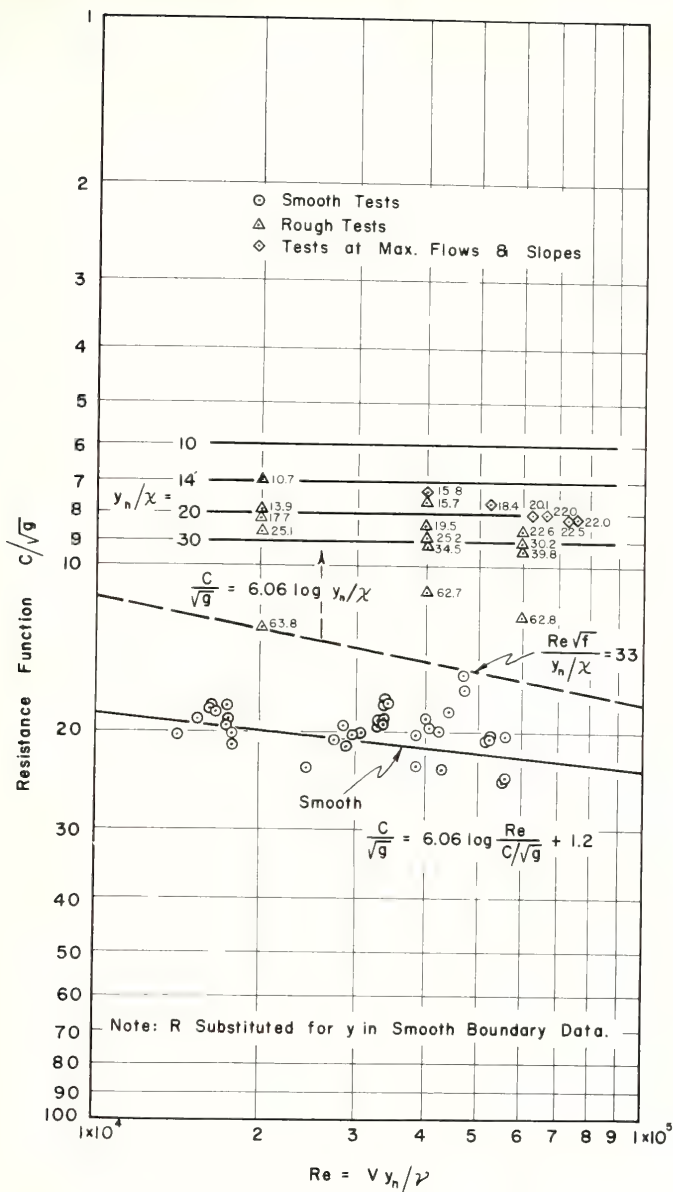


FIGURE 5-19 GENERAL RESISTANCE DIAGRAM FOR UNIFORM FLOW IN OPEN CHANNELS (SAYRE)





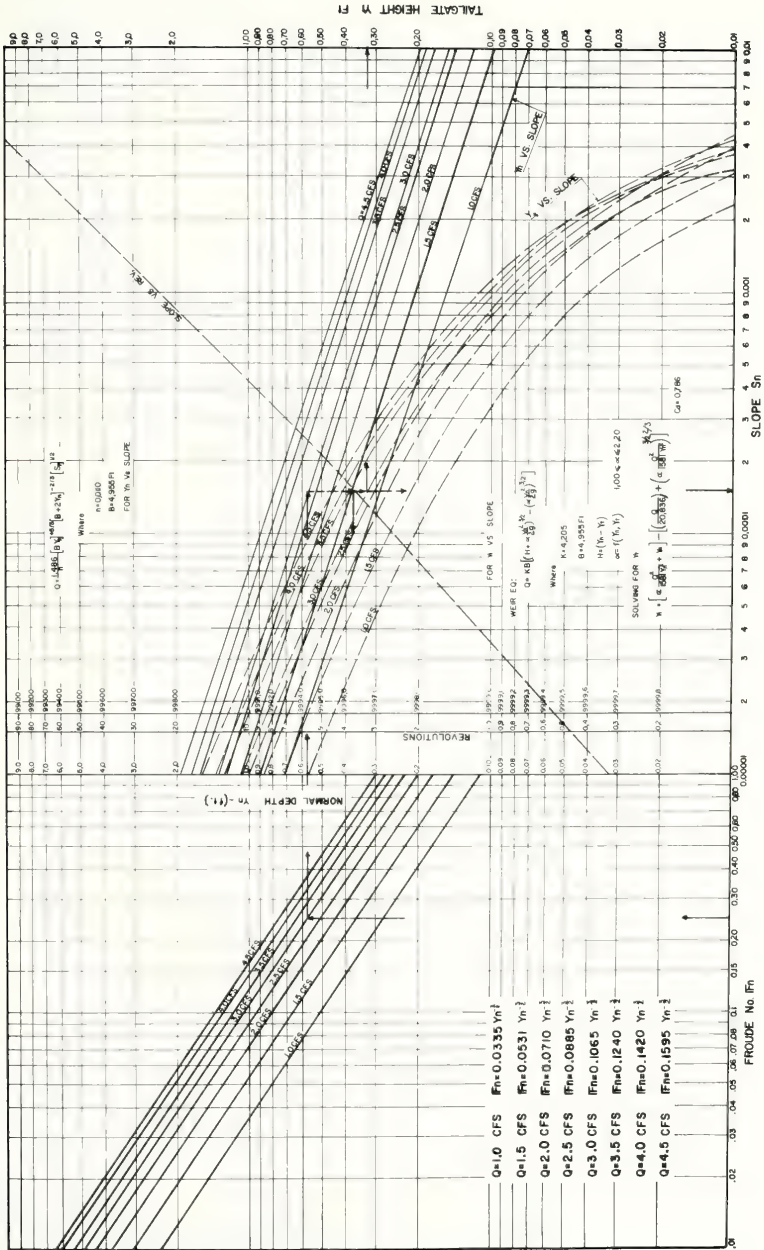


FIGURE 6-1 TESTS SELECTION CURVE - LARGE FLUME - SMOOTH BOUNDARIES







**PROGRAM FLOW CHART  
FOR DATA ANALYSIS**

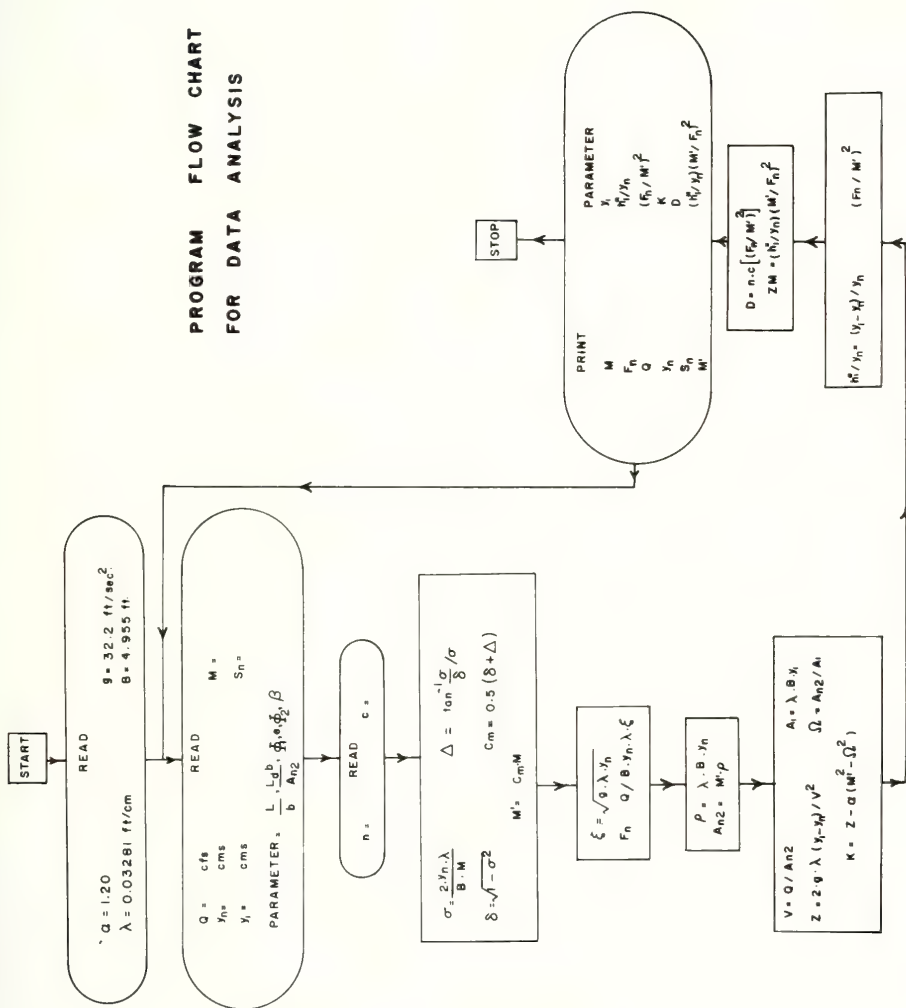


FIG. 6-3



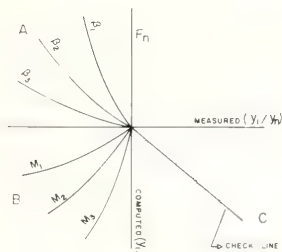


FIGURE 6-4

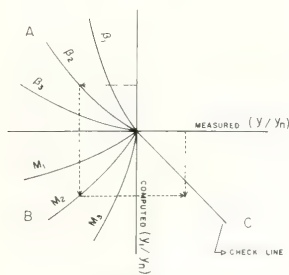


FIGURE 6-7

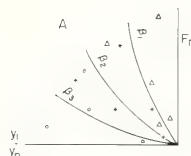


FIGURE 6-5

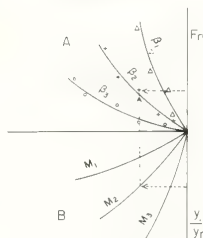


FIGURE 6-8

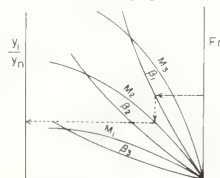


FIGURE 6-10

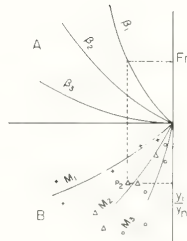


FIGURE 6-6

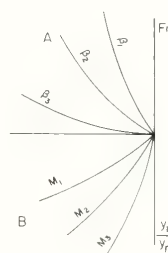


FIGURE 6-9

## FOUR VARIABLES GRAPHICAL MULTIPLE CORRELATION

$$\begin{aligned} M_1 &= 0.75 & \beta_1 &= 0.0 \\ M_2 &= 0.5 & \beta_2 &= 0.3 \\ M_3 &= 0.25 & \beta_3 &= 0.5 \end{aligned}$$

$$\bullet - \beta = 0.5, M = 0.25$$

$$+ - \beta = 0.3, M = 0.75$$

$$\Delta - \beta = 0.0, M = 0.5$$





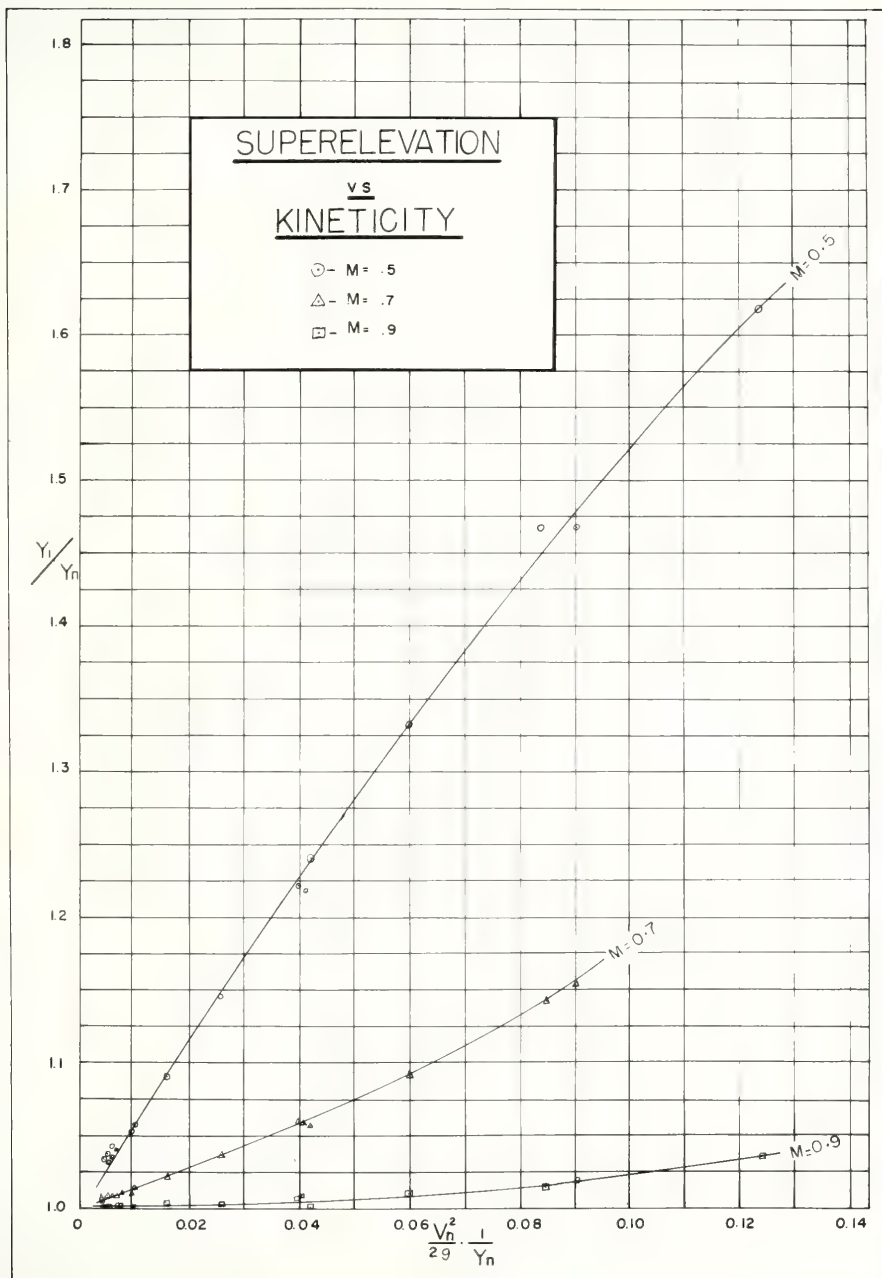


FIGURE 7-1-1



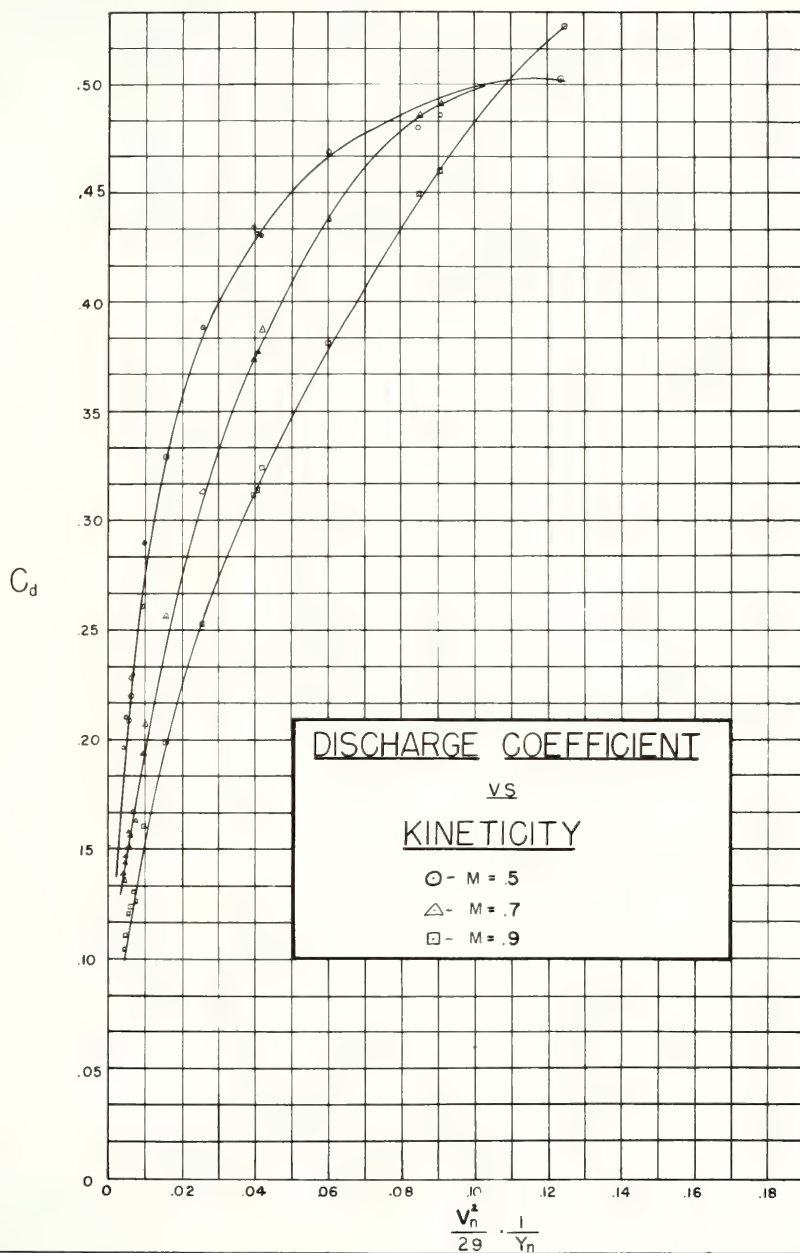
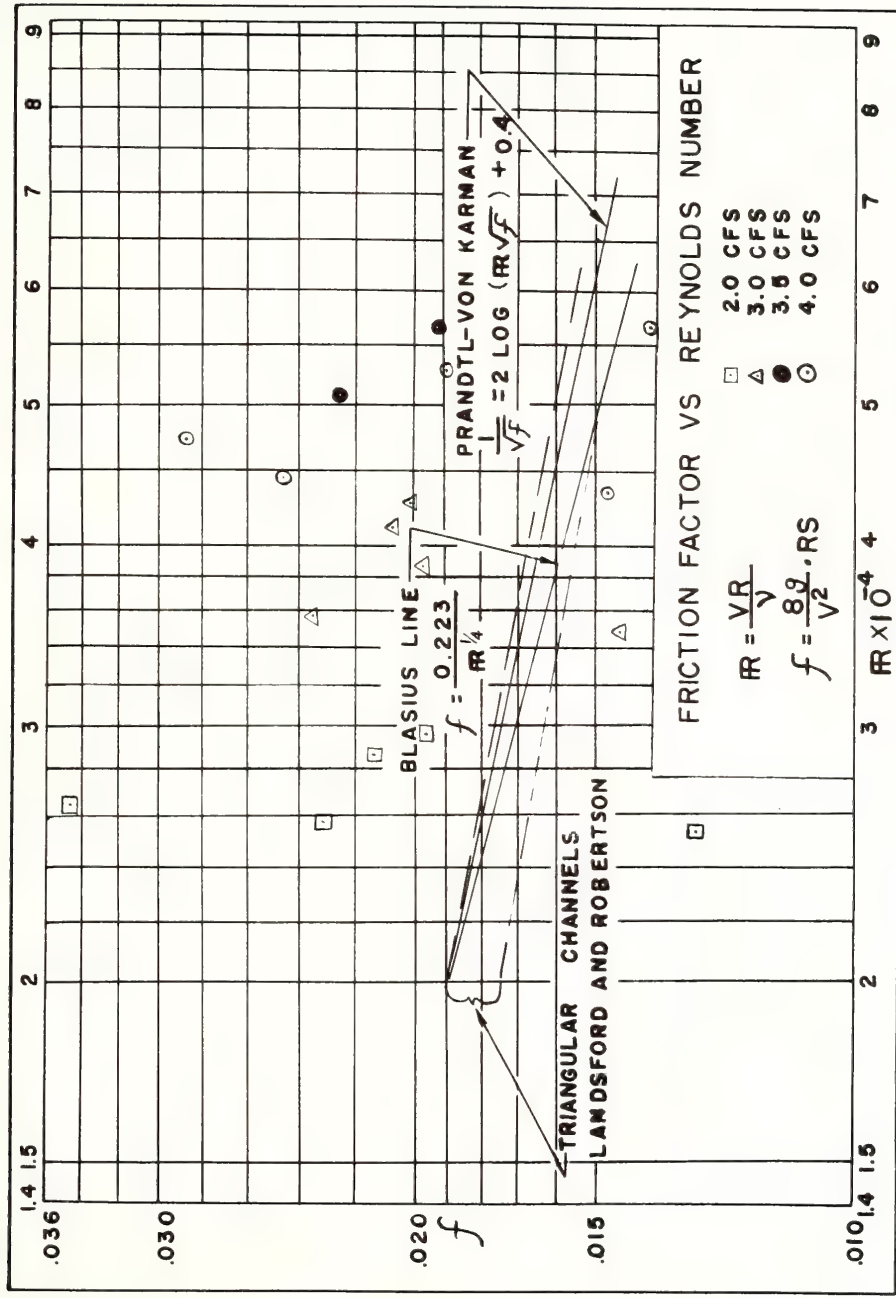


FIGURE 7-1-2



FIGURE 7-1-3





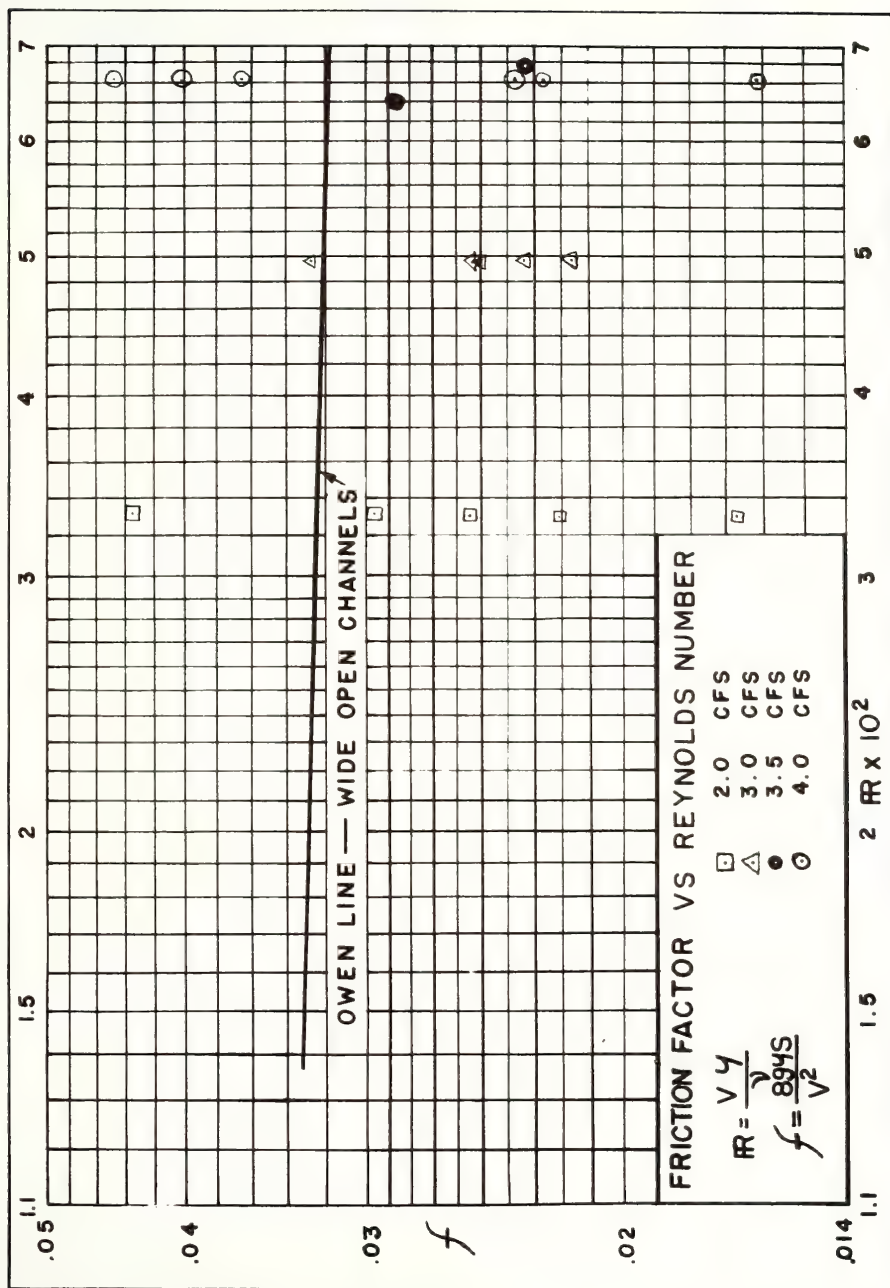


FIGURE 7-1-4





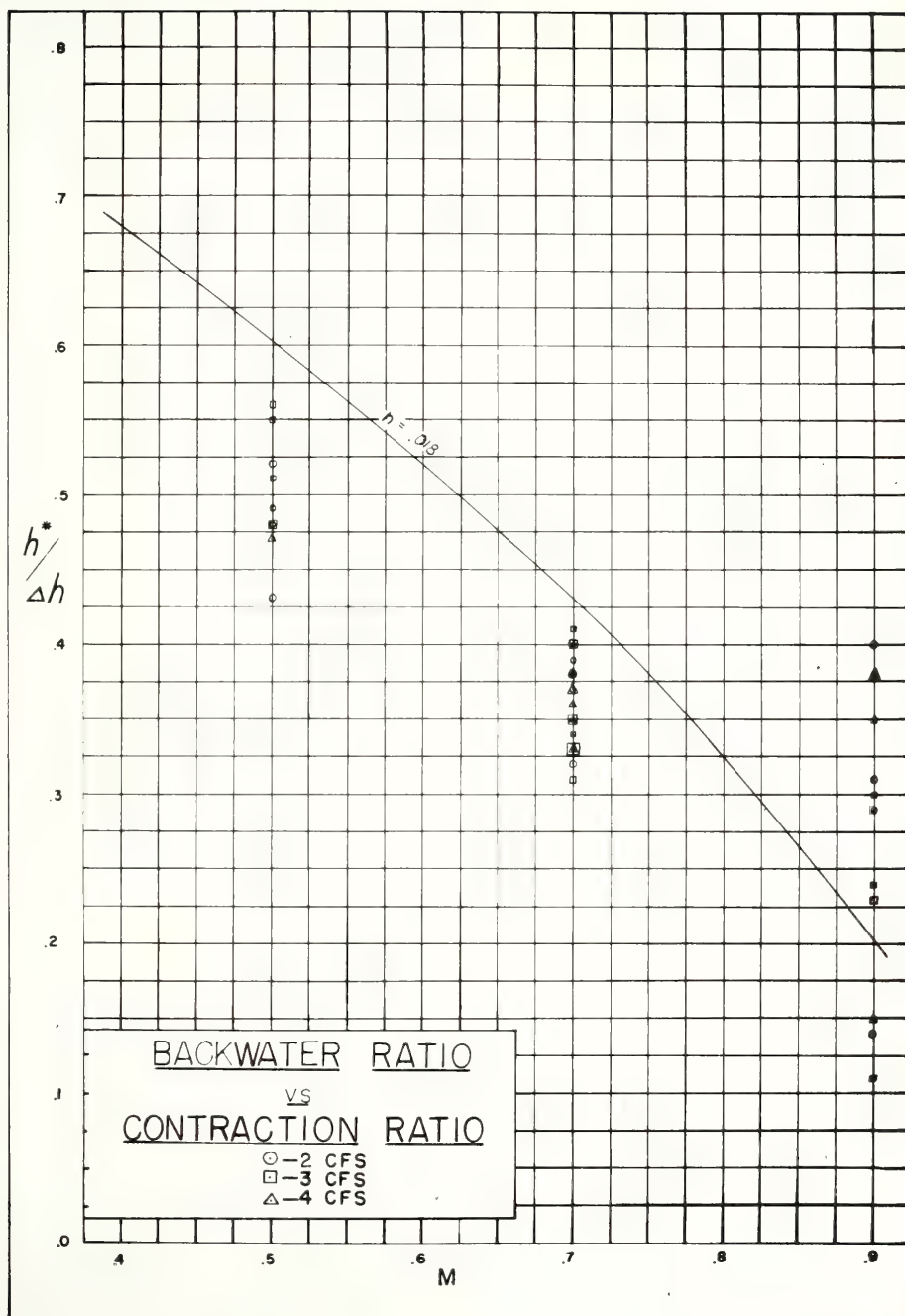


FIGURE 7-1-5



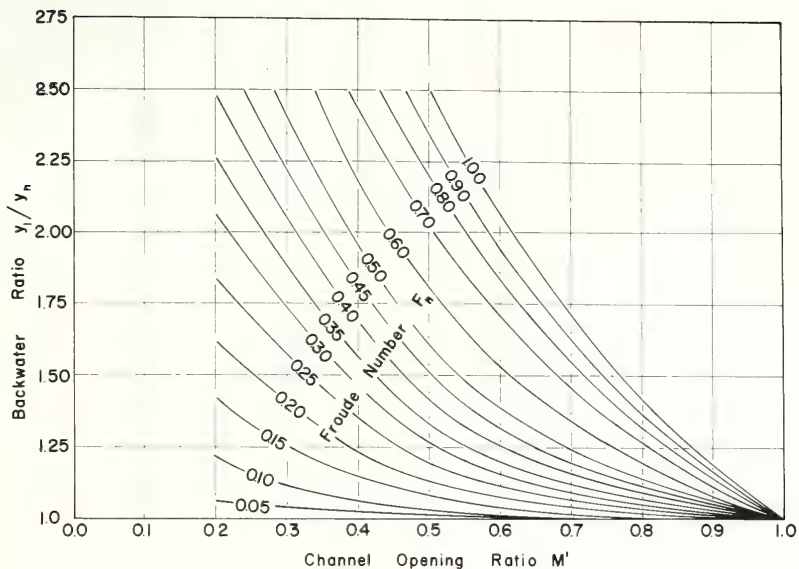


FIGURE 7-1-6 — BACKWATER RATIO VS CHANNEL OPENING RATIO  $L/b=0$  SEMI-CIRC. SMOOTH CHANNEL

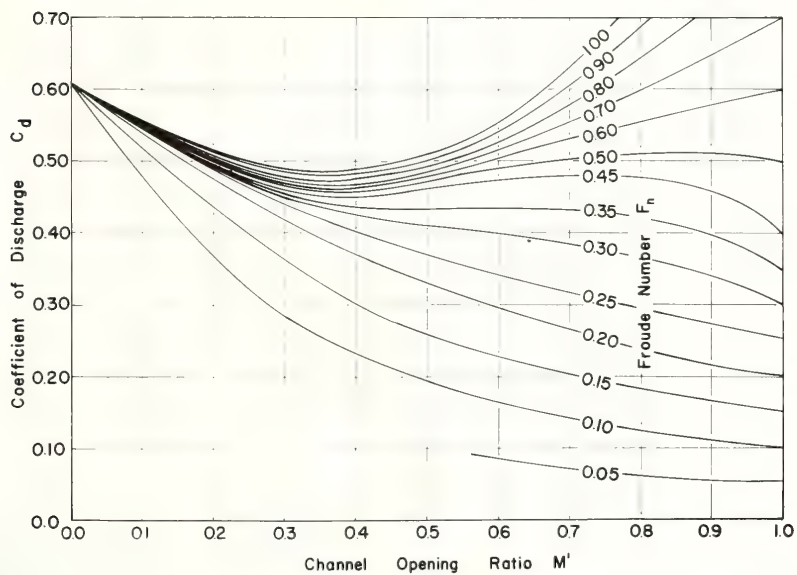


FIGURE 7-1-7 DISCHARGE COEF VS CHANNEL OPENING RATIO  $L/b=0$  SEMI-CIRC. SMOOTH CHANNEL



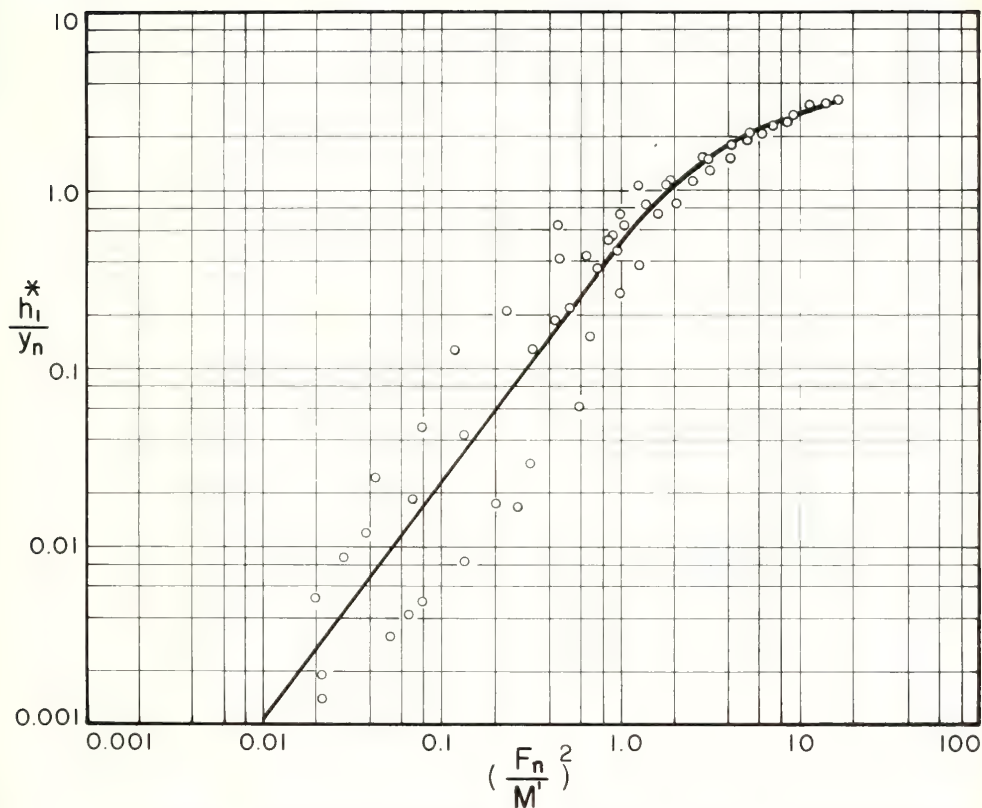


FIGURE 7-1-8 BACKWATER RATIO FOR GEOMETRY  $I_a$ , SMOOTH BOUNDARY  $\frac{L}{b} = 0.0$



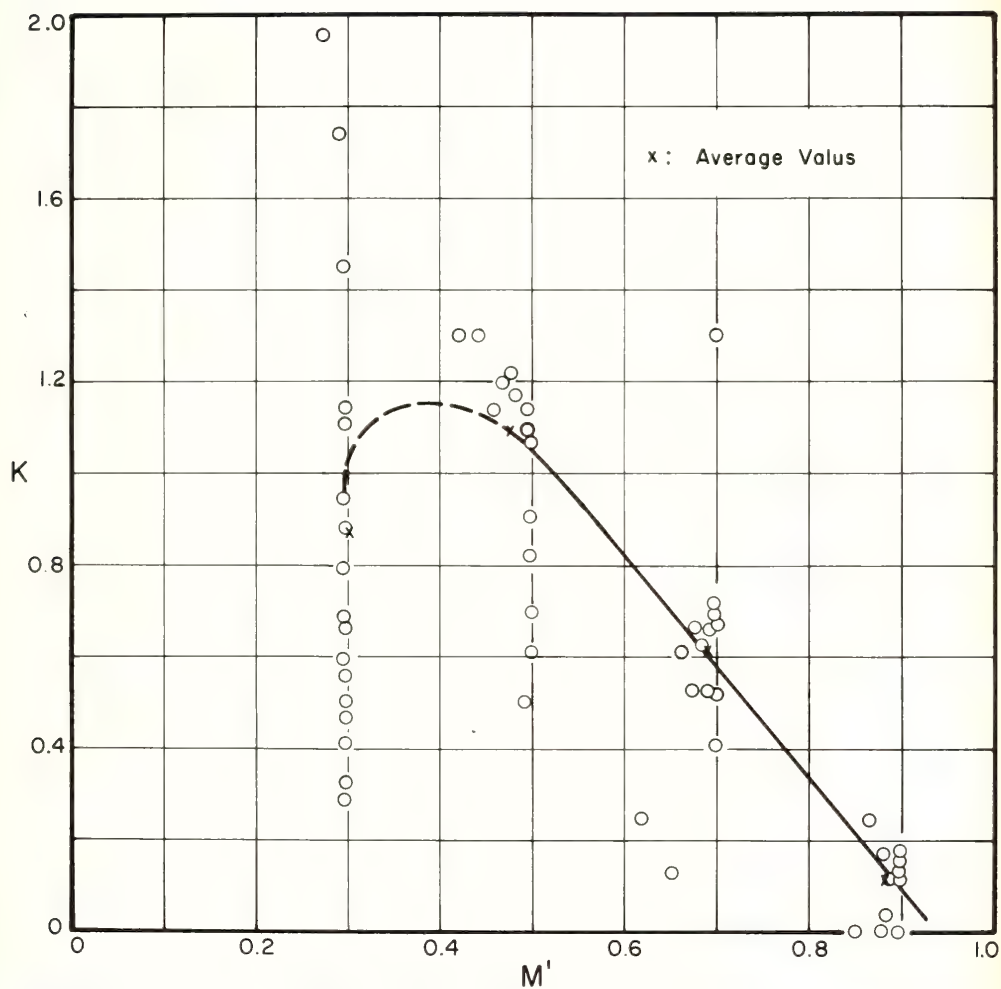


FIGURE 7-1-9 HEAD LOSS COEFFICIENT, GEOMETRY  $I_a$   
 SMOOTH BOUNDARY  $\frac{L}{b} = 0.0$





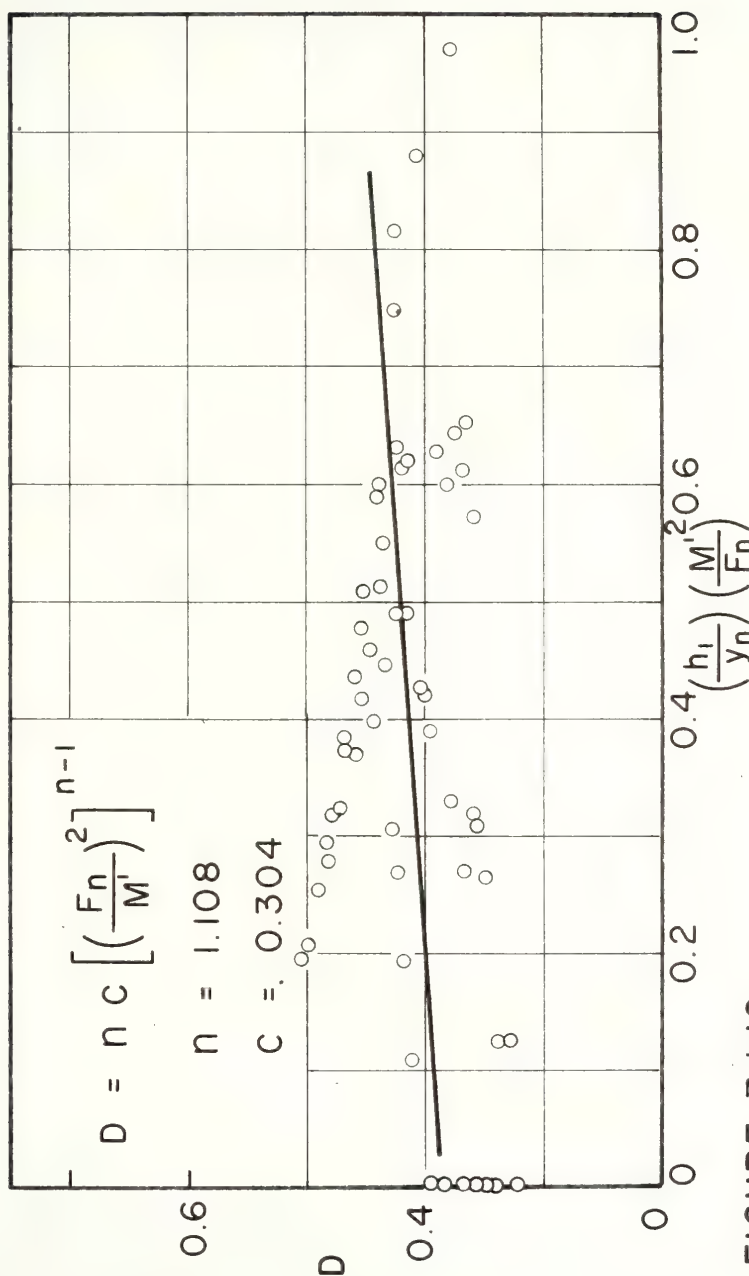


FIGURE 7-1-10 BACKWATER RATIO COEFFICIENT, GEOMETRY  $I_a$ , SMOOTH BOUNDARY  $\frac{L}{b} = 0.0$



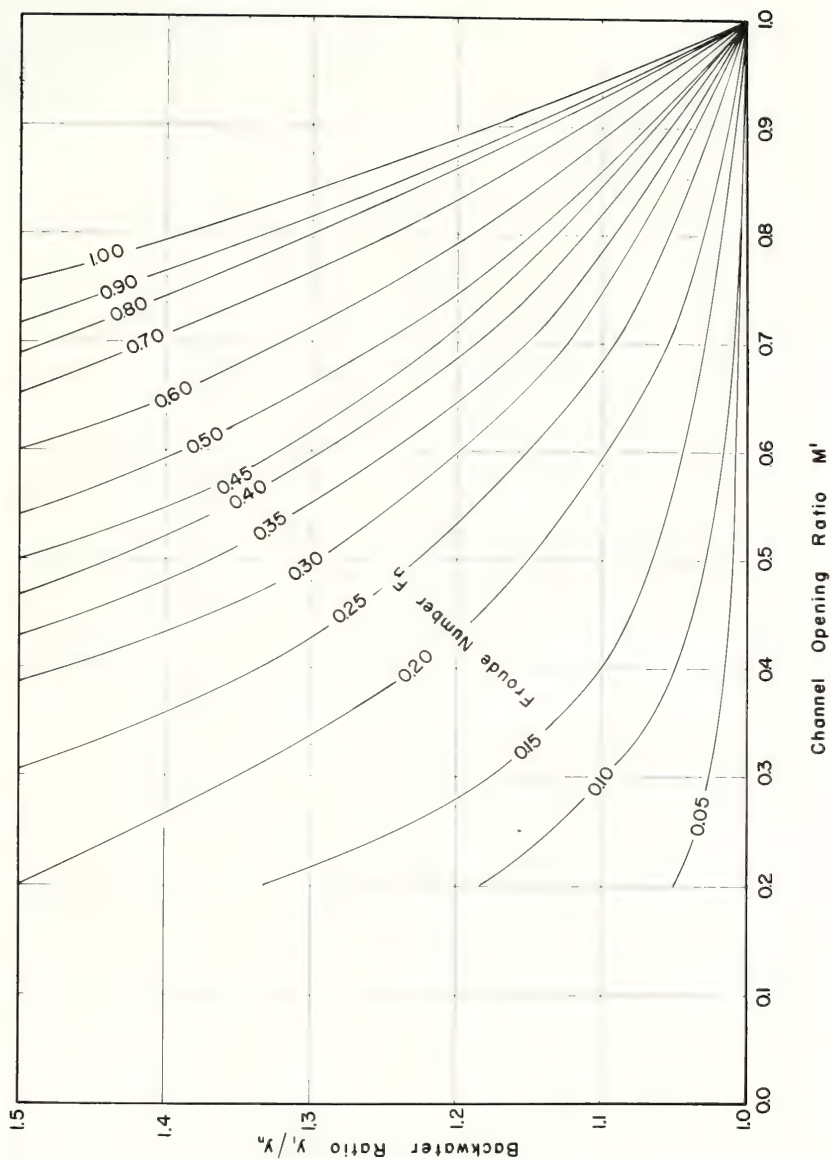


FIGURE 7-2-1a BACKWATER RATIO VS CHANNEL  
OPENING RATIO  $L/B=0$  SEMI-CIRC.  
ROUGH CHANNEL  $y_1/y_n \leq 1.50$



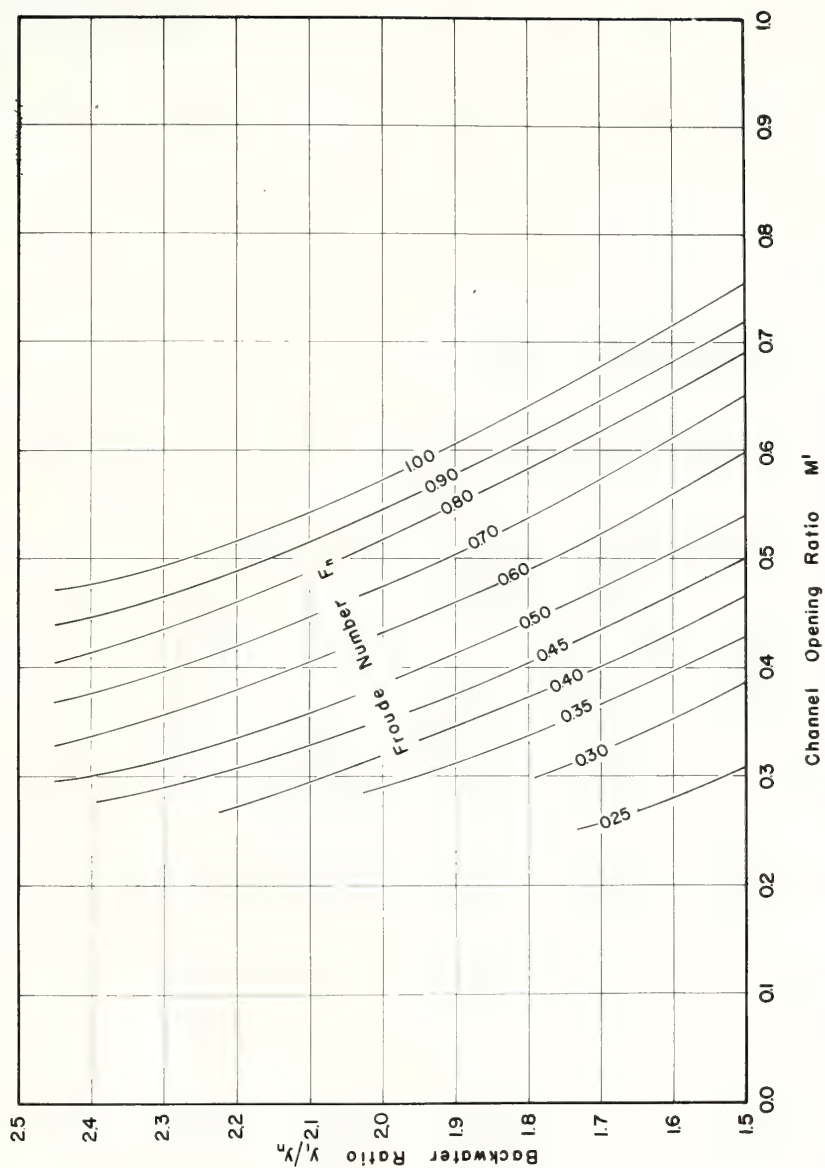


FIGURE 7-2-1<sub>b</sub> BACKWATER RATIO VS CHANNEL  
OPENING RATIO  $L/b=0$  SEMI-CIRC.  
ROUGH CHANNEL  $1.50 \leq y_1/y_n \leq 2.50$



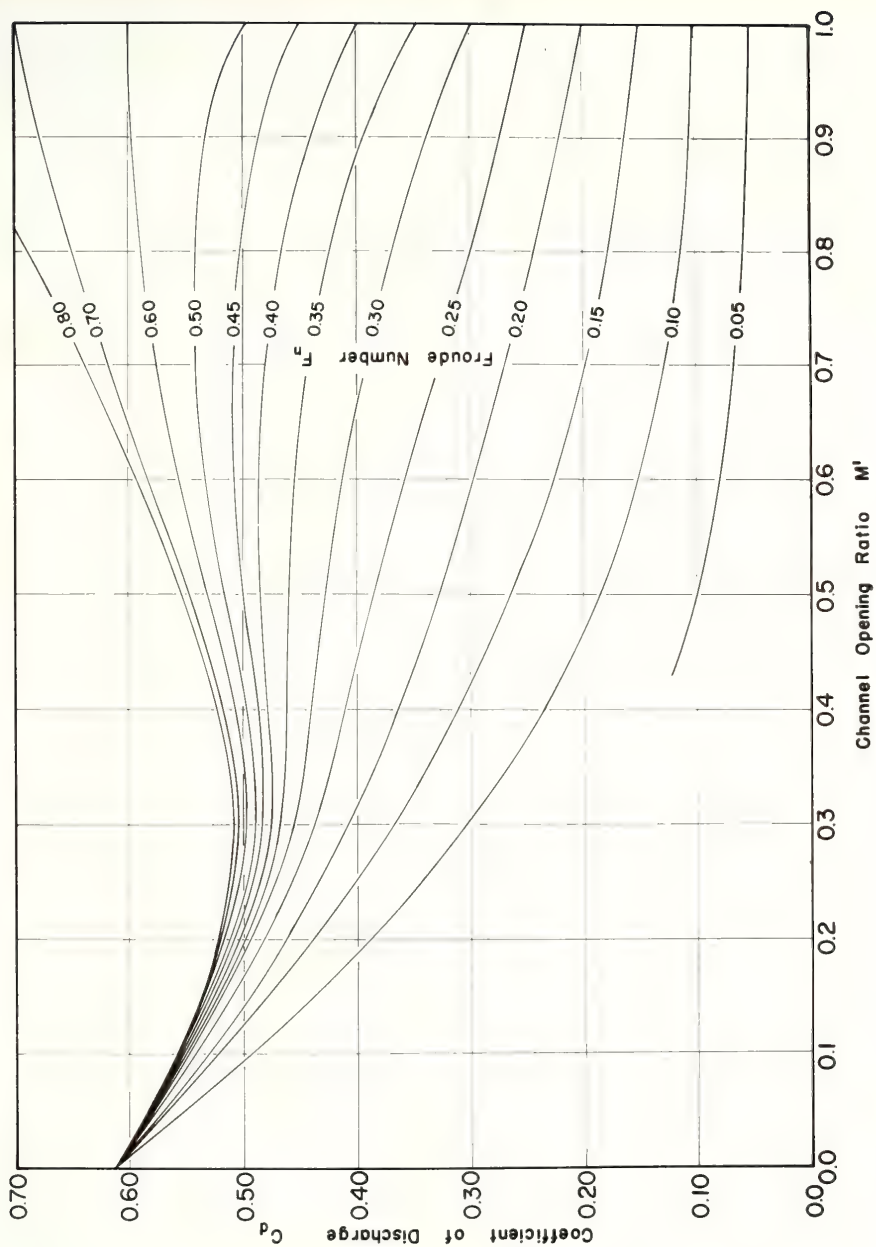
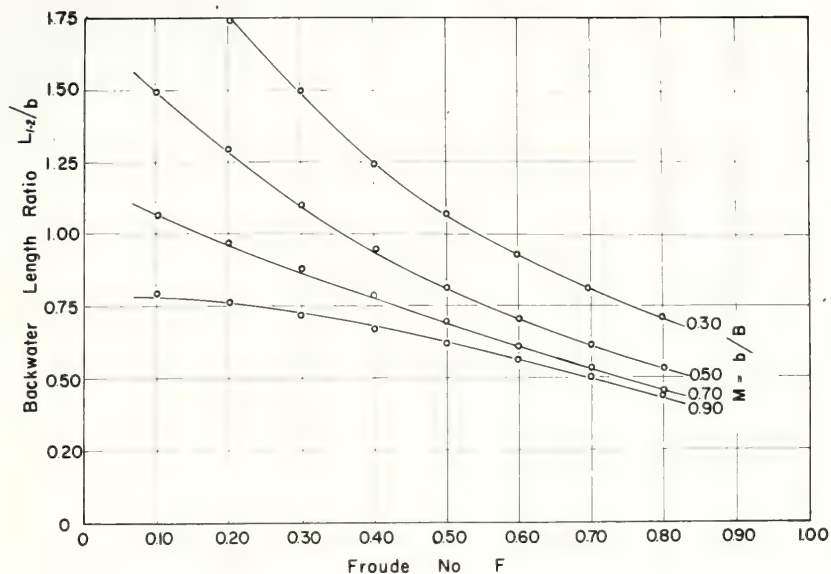
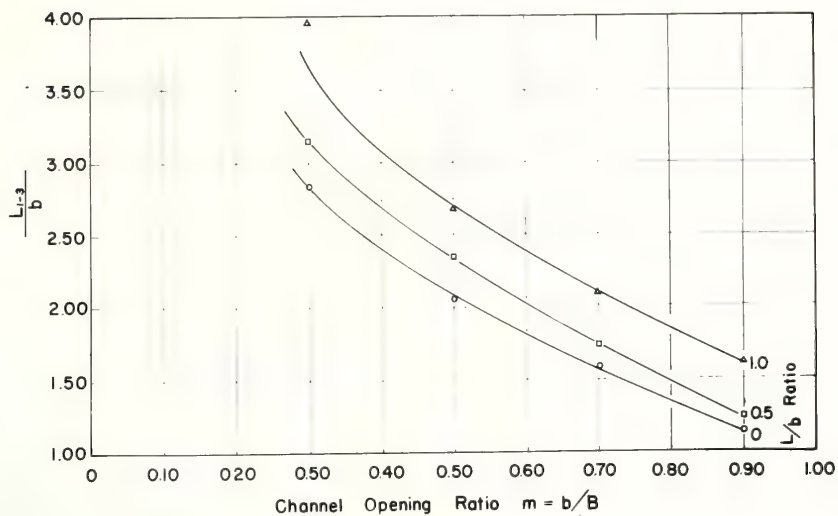


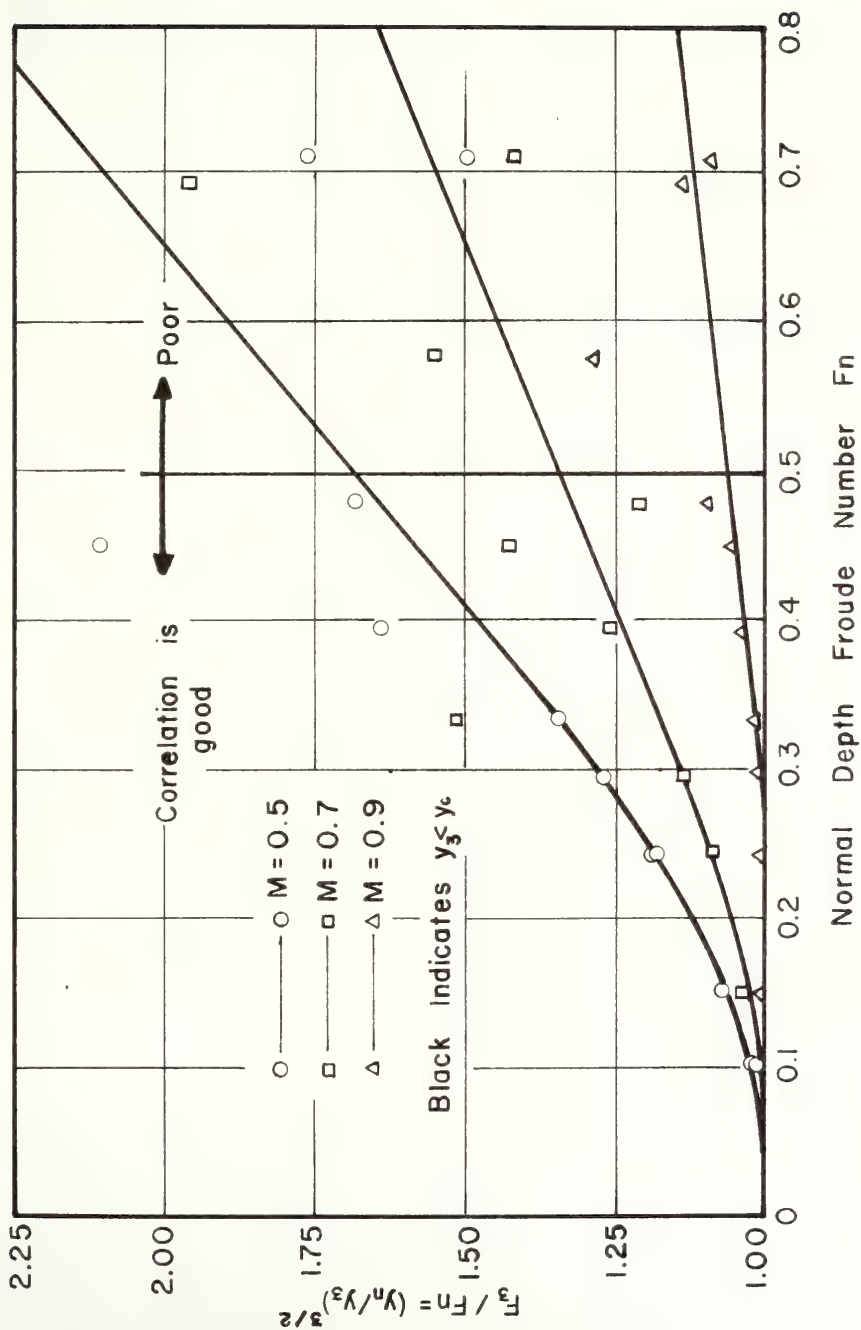
FIGURE 7-2-2 DISCHARGE COEF. VS CHANNEL OPENING  
RATIO  $L/b=0$  SEMI-CIRC. ROUGH CHANNEL





FIGURE 7-2-3<sub>a</sub> LENGTH TO MAXIMUM BACKWATERFIGURE 7-2-3<sub>b</sub> LENGTH OF SURFACE PROFILE BETWEEN  $y_1$  &  $y_2$



FIG 7-2-4 CORRELATION CURVE OF  $F_3$



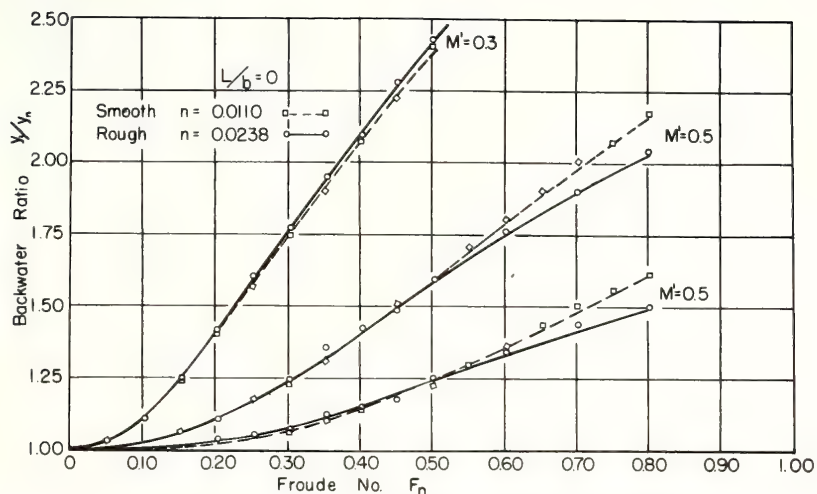


FIG. 7-2-5a COMPARISON BETWEEN BACKWATER RATIOS IN SMOOTH AND ROUGH CHANNELS

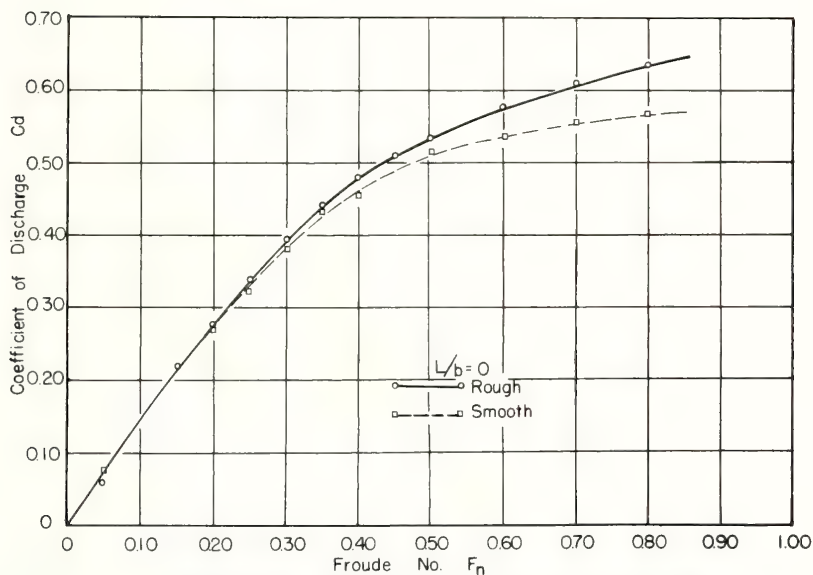


FIG. 7-2-5b COMPARISON OF  $C_d$  TO  $F_n$  FOR THE TWO ROUGHNESS CONDITIONS  $M=0.7$



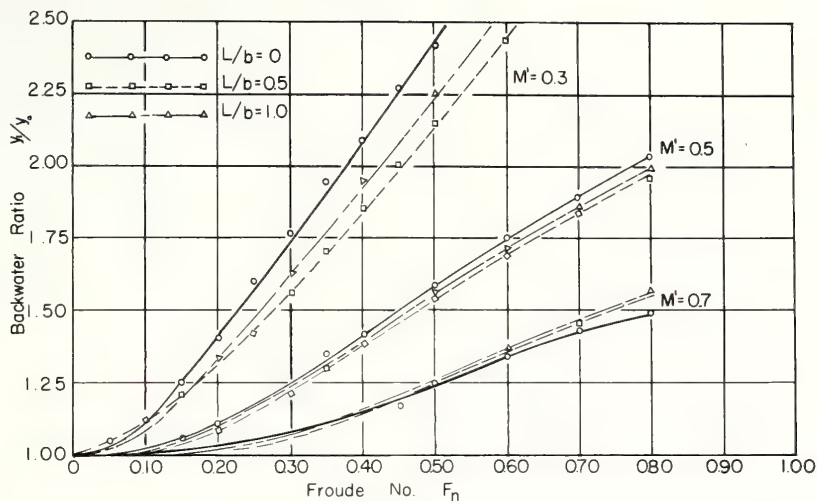


FIG. 7-2-6<sub>a</sub> COMPARISON BETWEEN BACKWATER RATIOS FOR BRIDGE LENGTHS-ROUGH CHANNEL

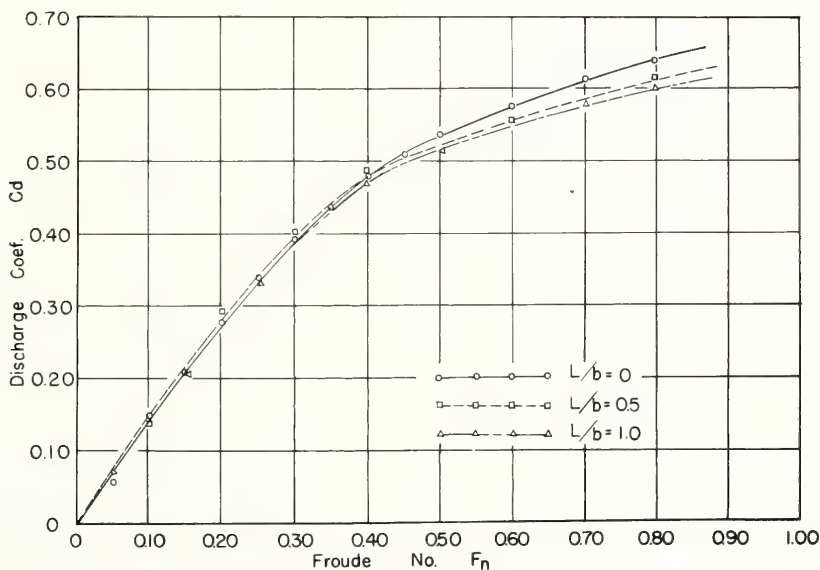


FIG. 7-2-6<sub>b</sub> COMPARISON BETWEEN DISCHARGE COEFFICIENTS FOR BRIDGE LENGTHS -  $M' = 0.7$





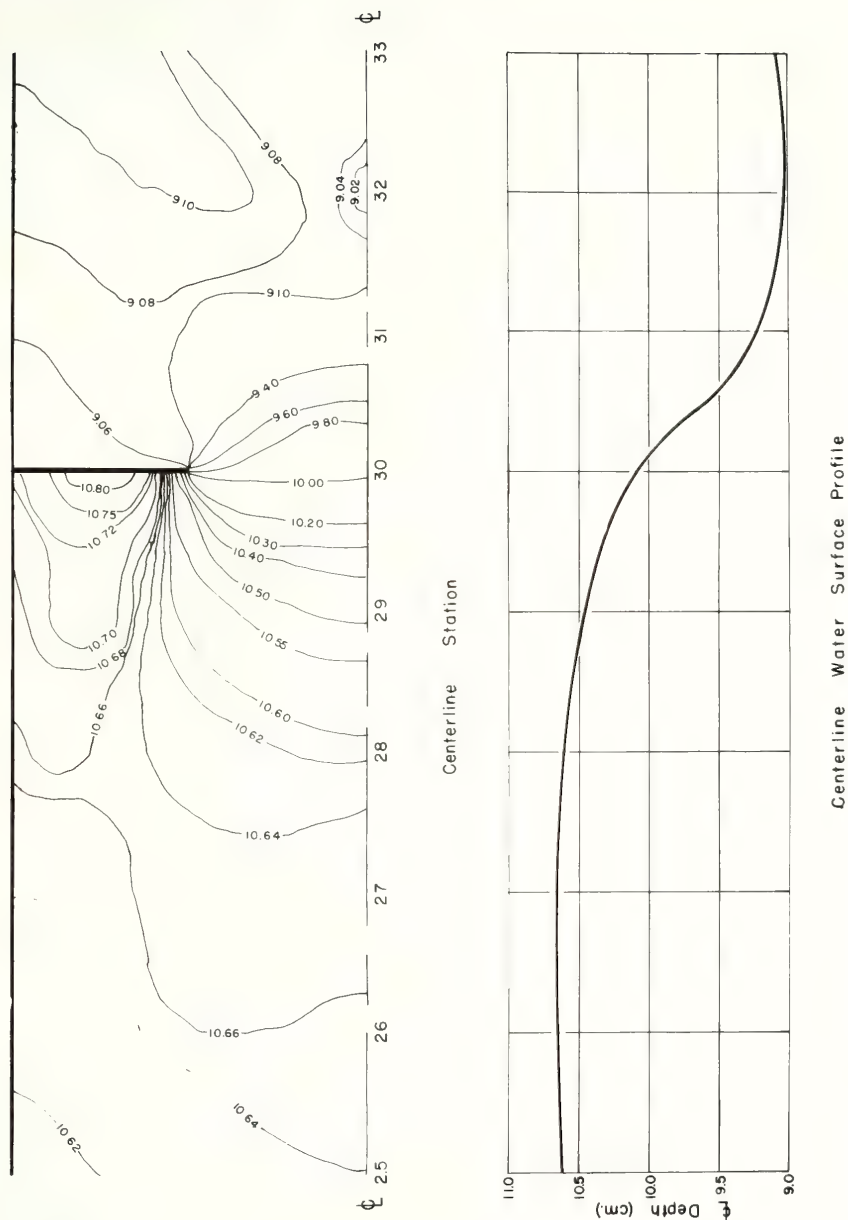


FIGURE 7-2-7 SURFACE TOPOGRAPHY  $Q = 1$  CFS,  
 $S = 0.000584$ ,  $M = 0.5$ ,  $L/b = 0$



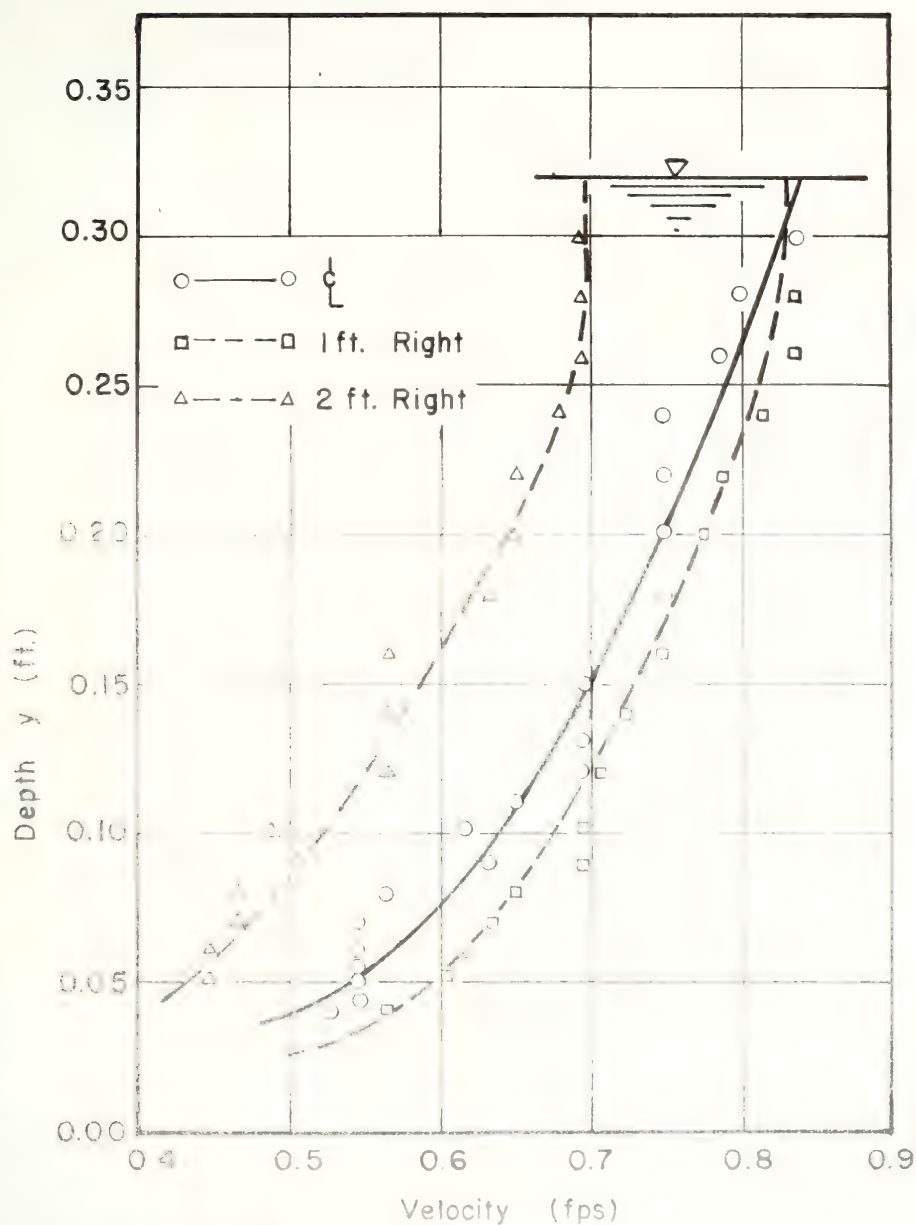


FIG. 1-2-B VELOCITY PROFILES AT MAXIMUM BACKWATER.  $Q=10$  CFS,  $540$  CUMICZ,  $M=0.5$ ,  $L/b=1$



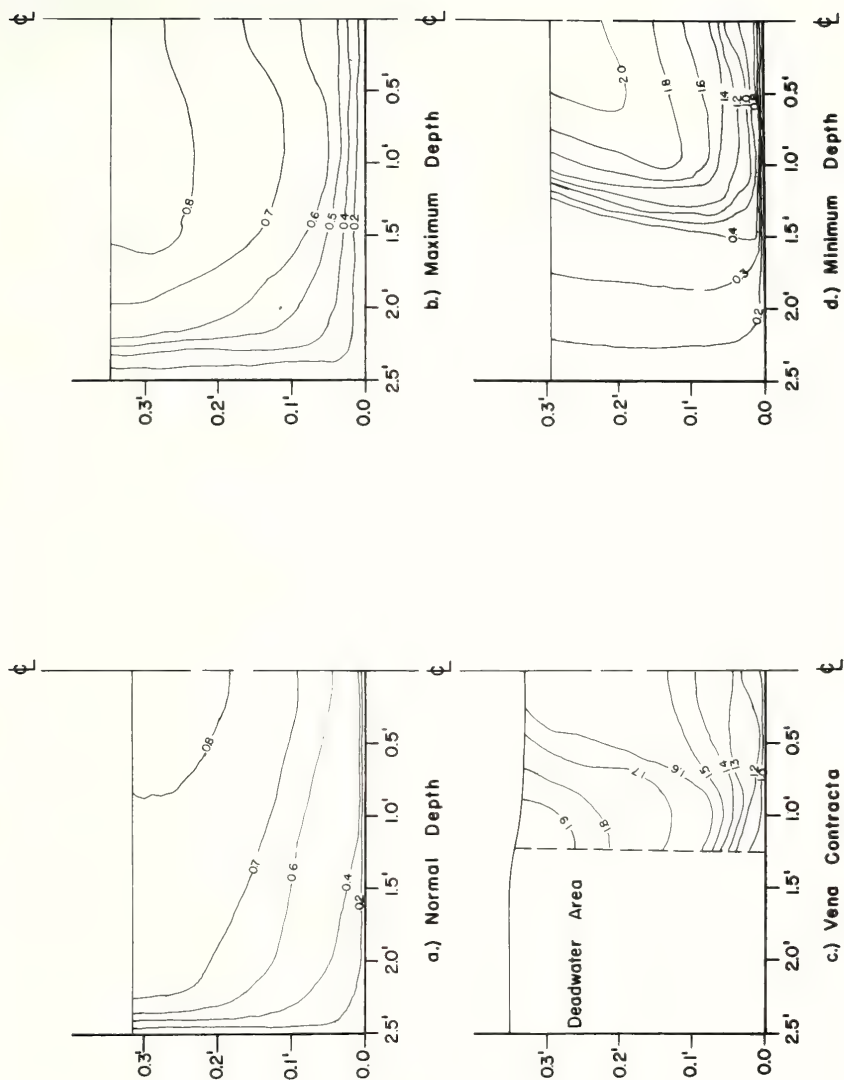


FIG. 7-2-9 ISOVEL DIAGRAMS IN FPS  $Q=1\text{CFS}$ ,  
 $S=0.000584$ ,  $M=0.5$ ,  $L/b=0$



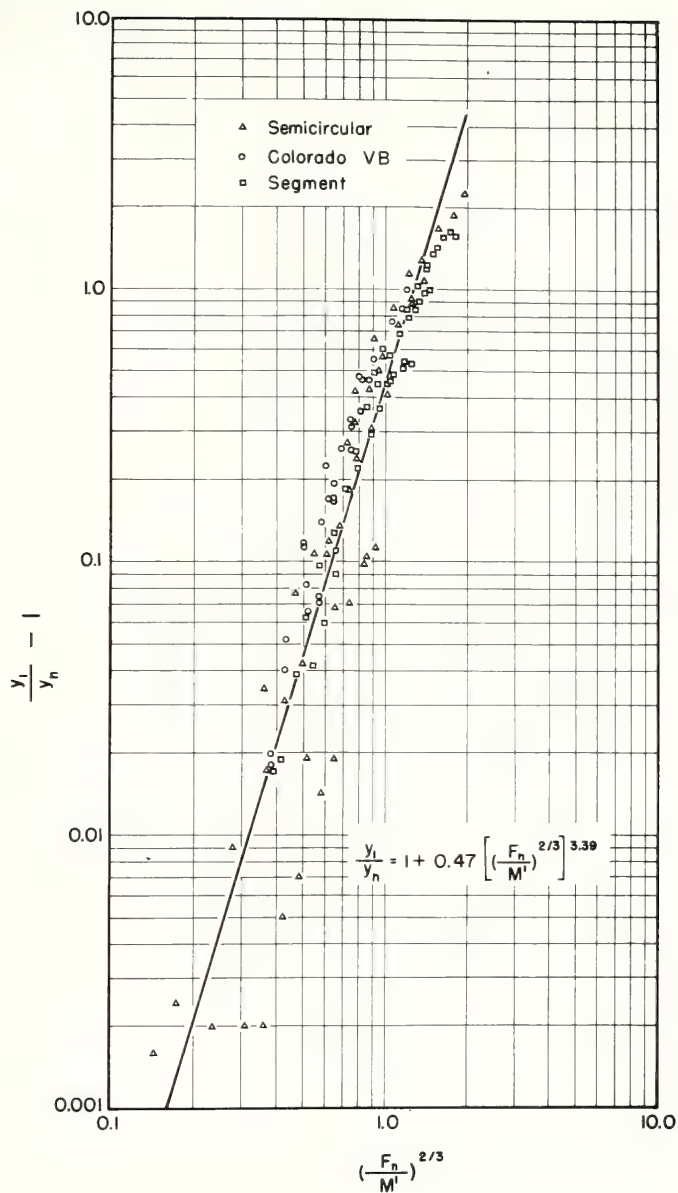


FIGURE 7-2-10 GENERALIZED BACKWATER RATIO





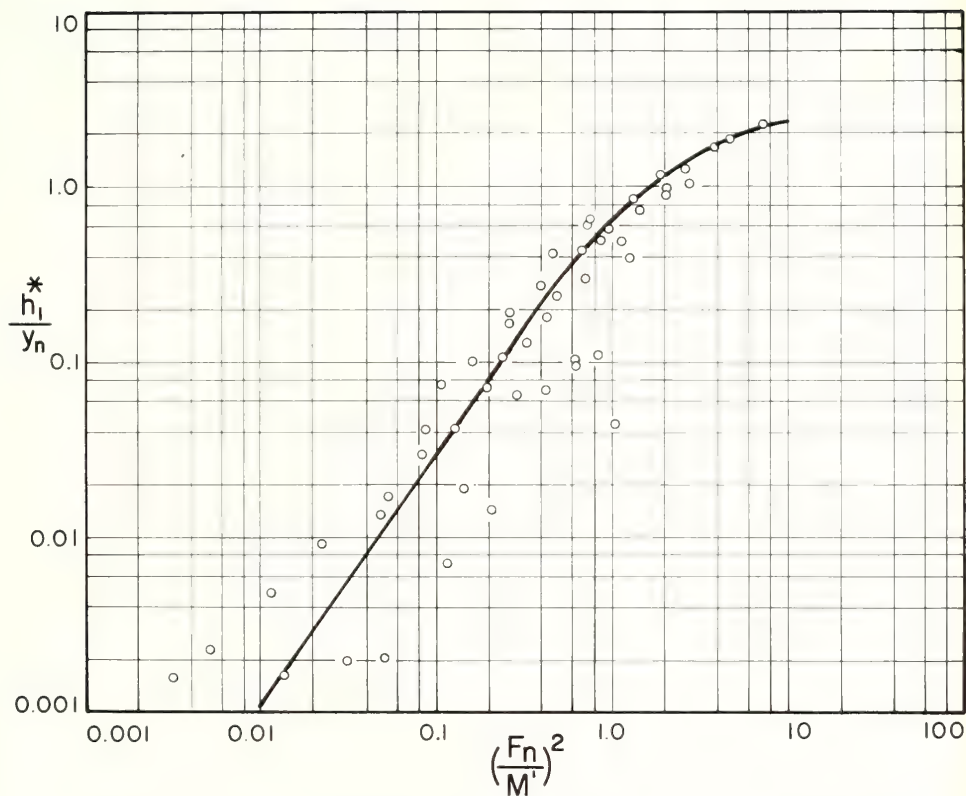


FIGURE 7-2-11 BACKWATER RATIO FOR GEOMETRY  $I_a$ , ROUGH BOUNDARY  $\frac{L}{b} = 0.0$



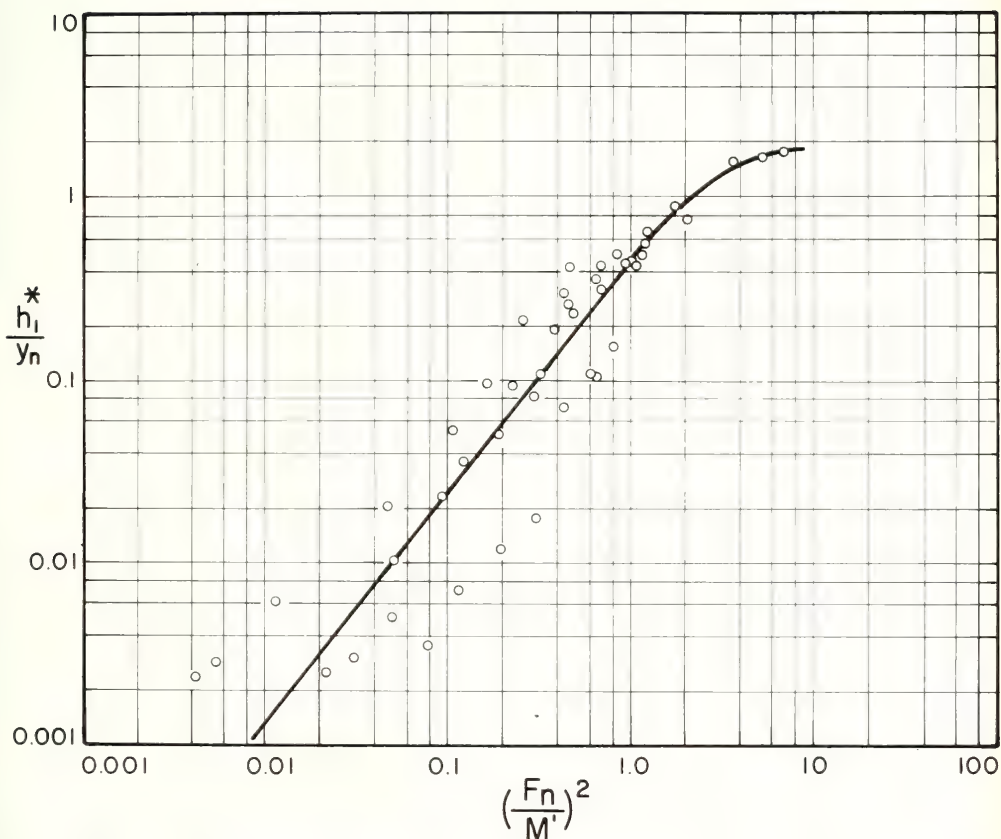


FIGURE 7-2-12 BACKWATER RATIO FOR GEOMETRY  $I_b$ , ROUGH BOUNDARY  $\frac{L}{b} = 0.5$



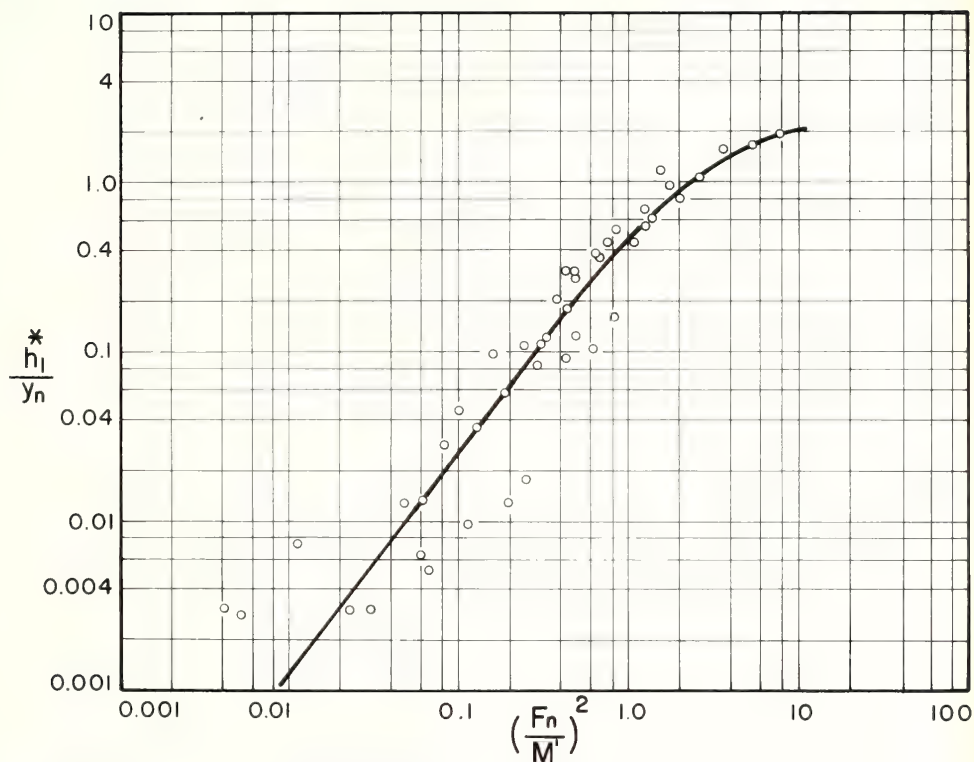


FIGURE 7-2-13 BACKWATER RATIO FOR GEOMETRY  $I_b$   
ROUGH BOUNDARY  $\frac{L}{b} = 1.0$



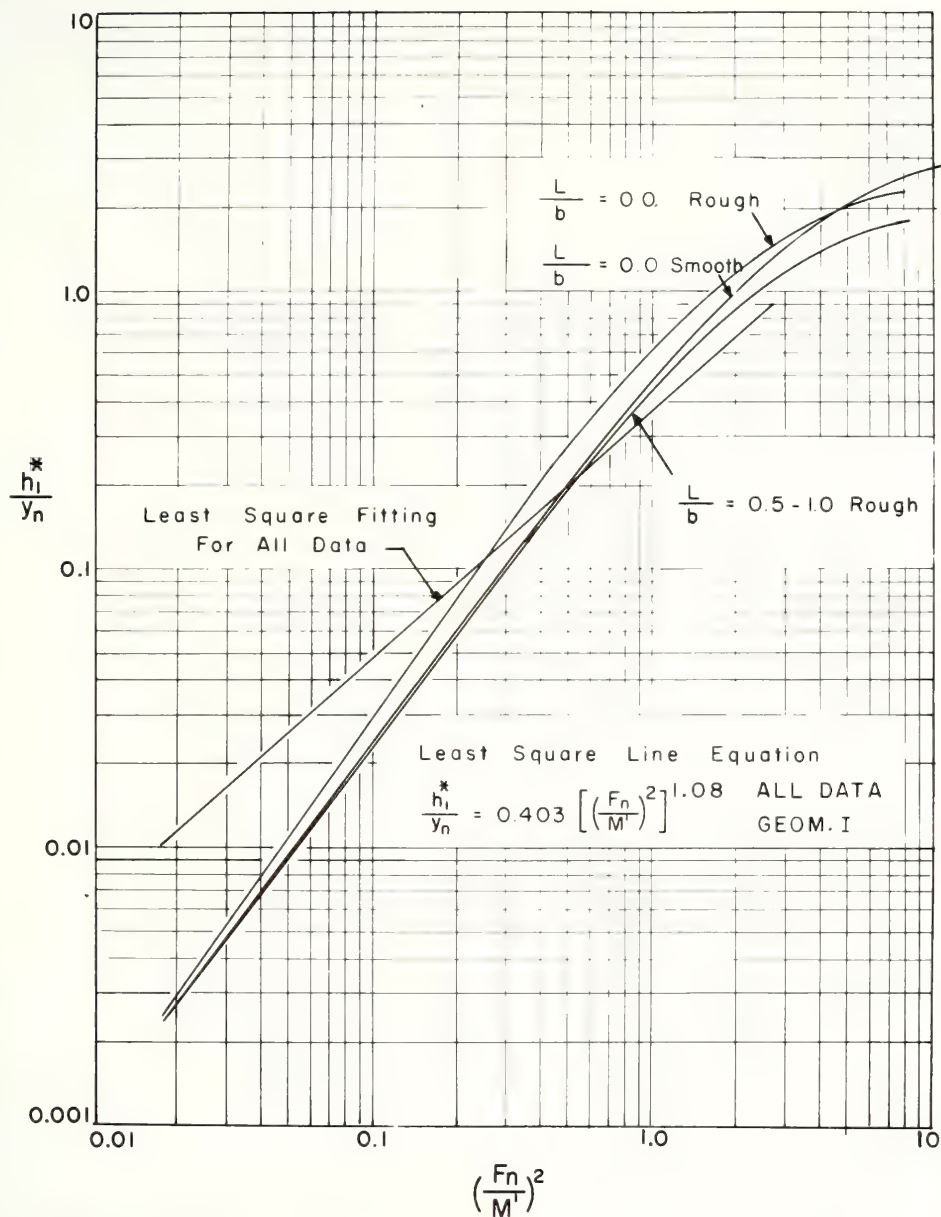


FIGURE 7-2-14 SUMMARY OF BACKWATER RATIO, GEOMETRY I, ROUGH & SMOOTH BOUNDARIES





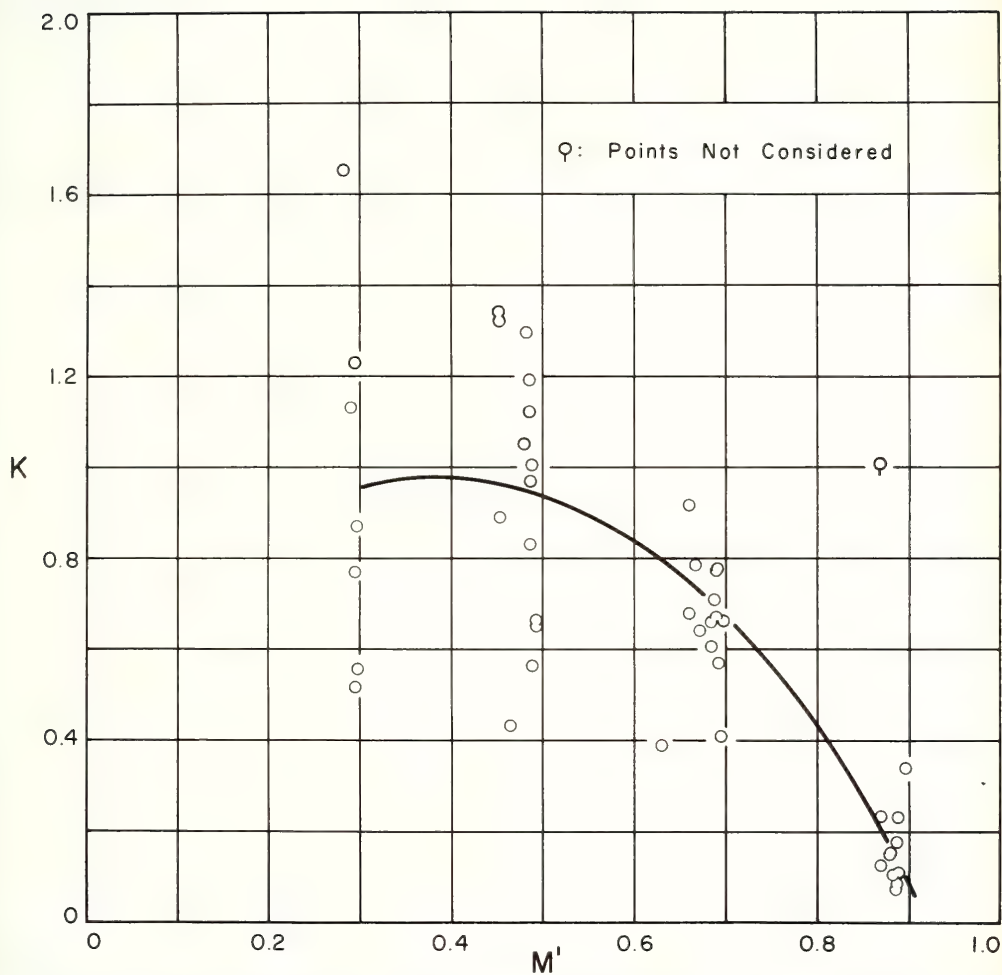


FIGURE 7-2-15 HEAD LOSS COEFFICIENT, GEOMETRY  $I_a$   
ROUGH BOUNDARY,  $\frac{L}{B} = 0.00$



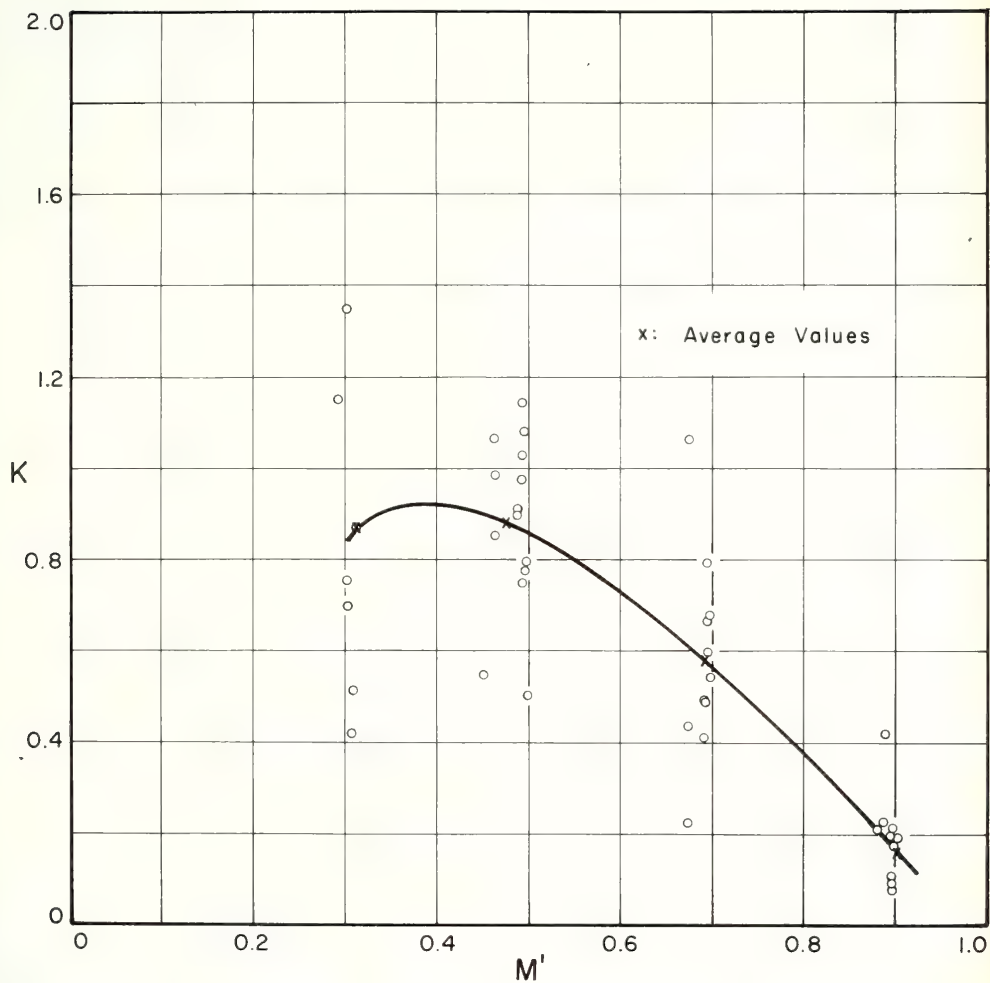


FIGURE 7-2-16 HEAD LOSS COEFFICIENT, GEOMETRY  $I_b$   
ROUGH BOUNDARY  $\frac{L}{b} = 0.5$



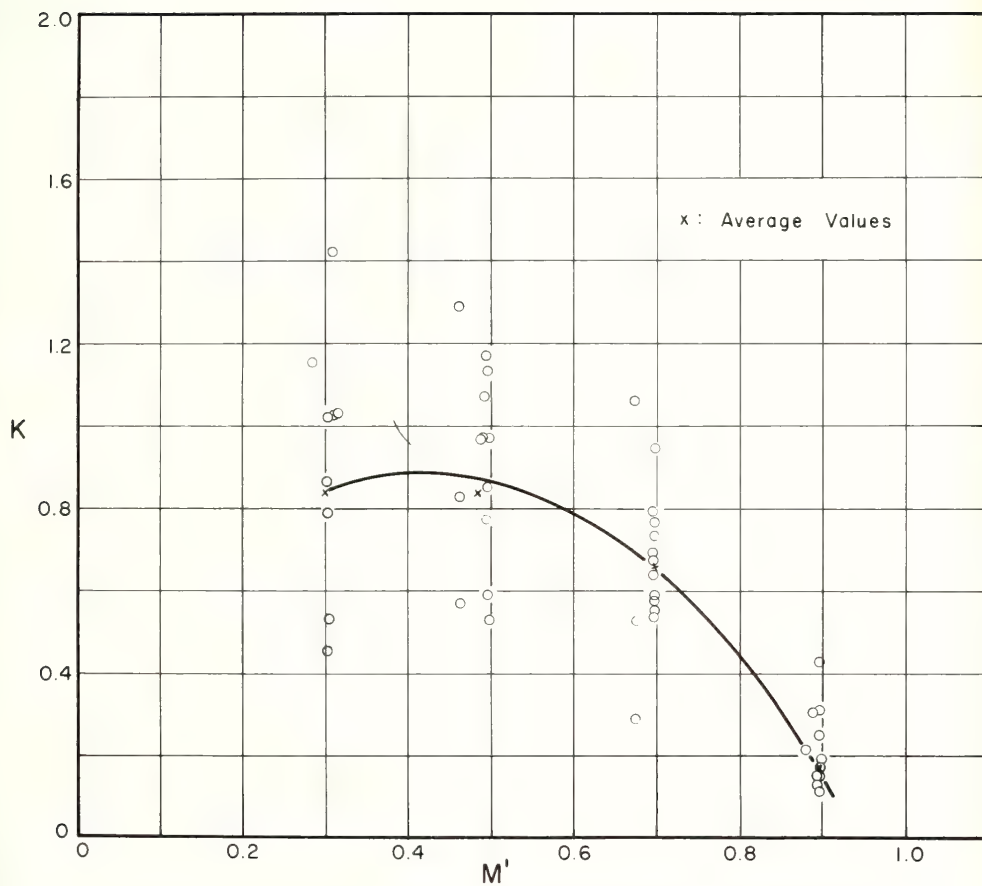


FIGURE 7-2-17 HEAD LOSS COEFFICIENT, GEOMETRY  $I_b$

ROUGH BOUNDARY  $\frac{L}{b} = 1.0$



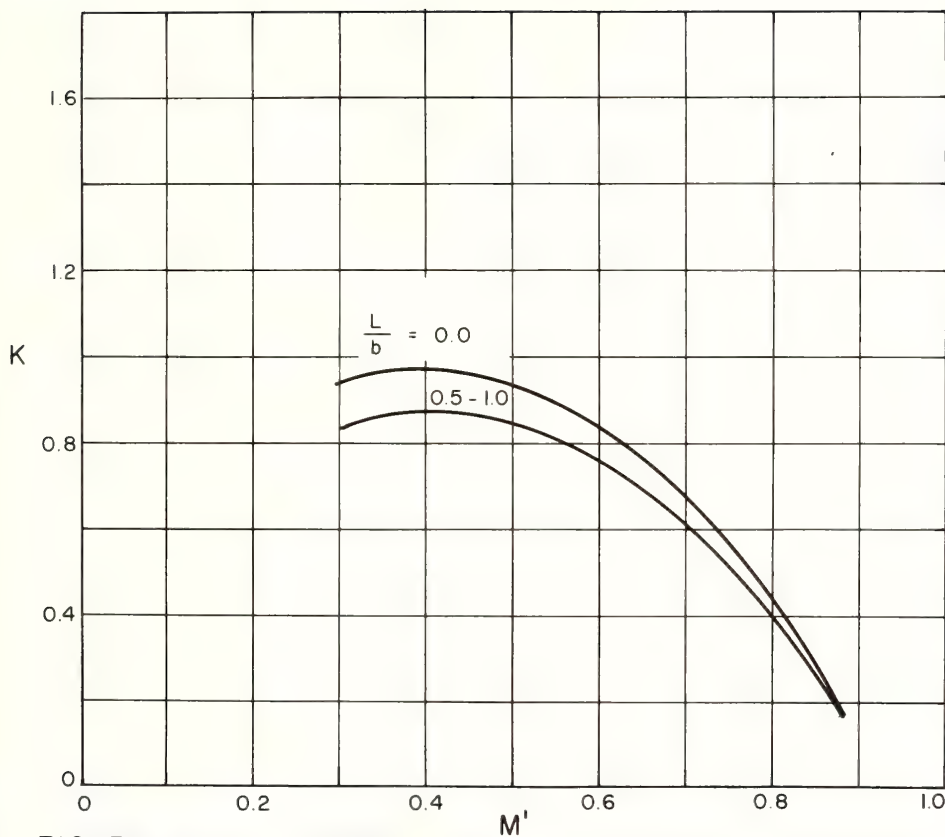


FIGURE 7-2-18 SUMMARY OF HEAD LOSS COEFFICIENTS  
GEOMETRY  $I_a$  &  $I_b$ , ROUGH BOUNDARY





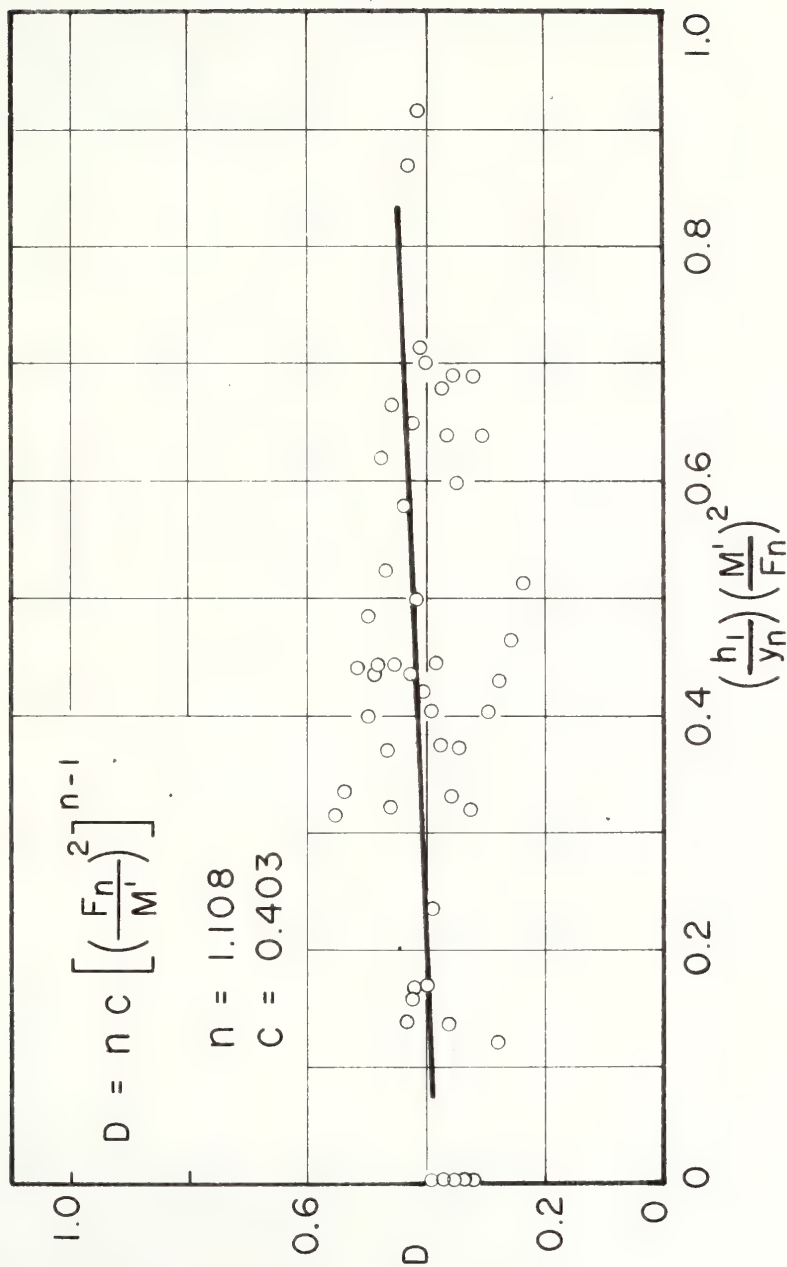


FIGURE 7-2-19 BACKWATER RATIO COEFFICIENT, GEOMETRY Ia  
 ROUGH BOUNDARY  $\frac{L}{b} = 0.00$



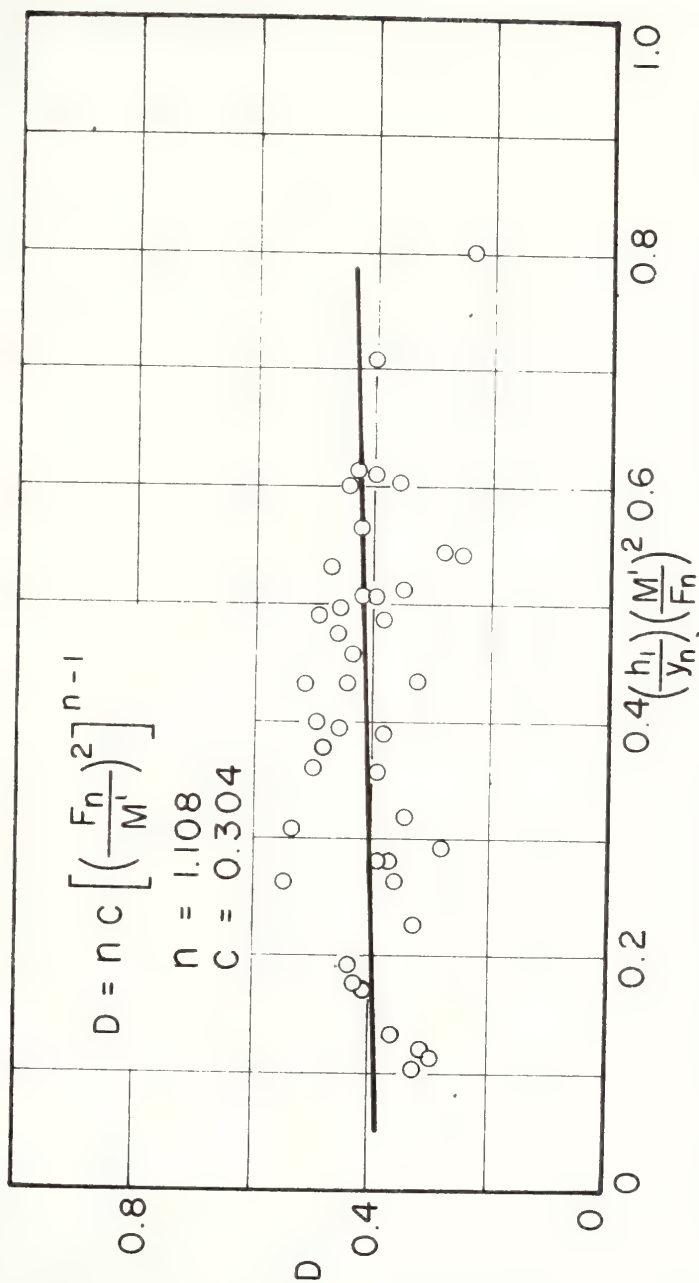
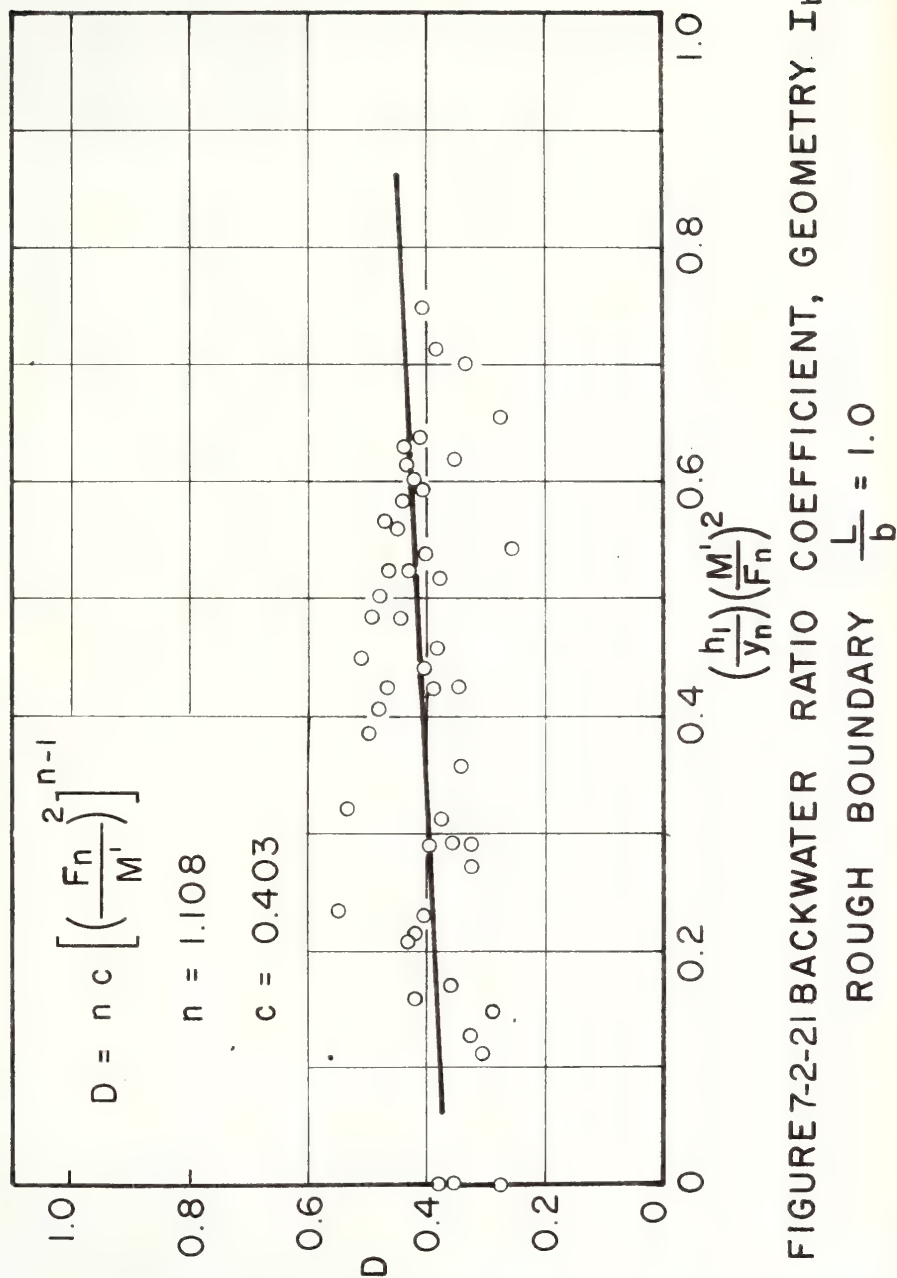
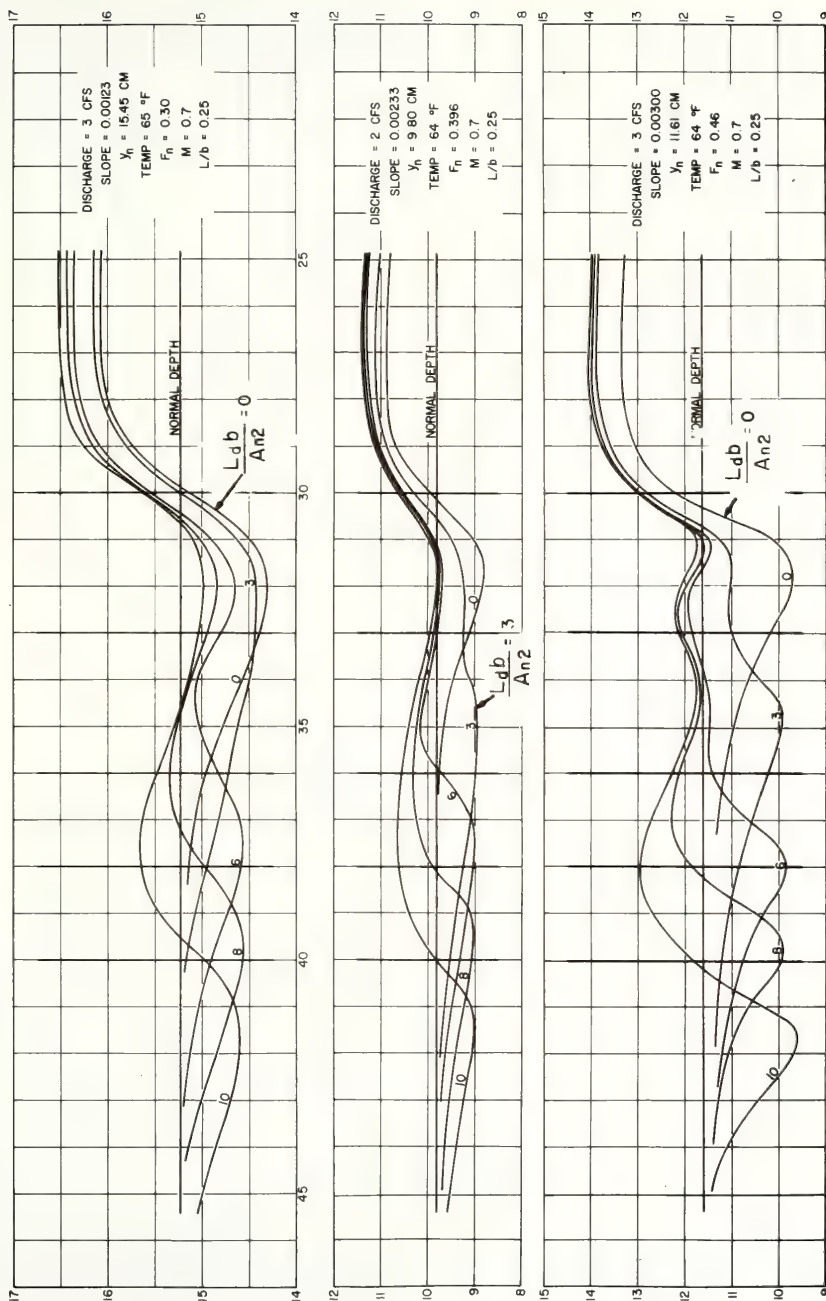


FIGURE 7-2-20 BACKWATER RATIO COEFFICIENT, GEO-METRY  $I_b$ , ROUGH BOUNDARY  $\frac{L}{b} = 0.5$



FIGURE 7-2-2| BACKWATER RATIO COEFFICIENT, GEOMETRY.  $I_b$





MEASURED WATER SURFACE PROFILES ALONG THE CENTERLINE FOR THREE DIMENSIONAL  
DUAL PARALLEL ARCH BRIDGE MODELS  
FIG. 7-3-0





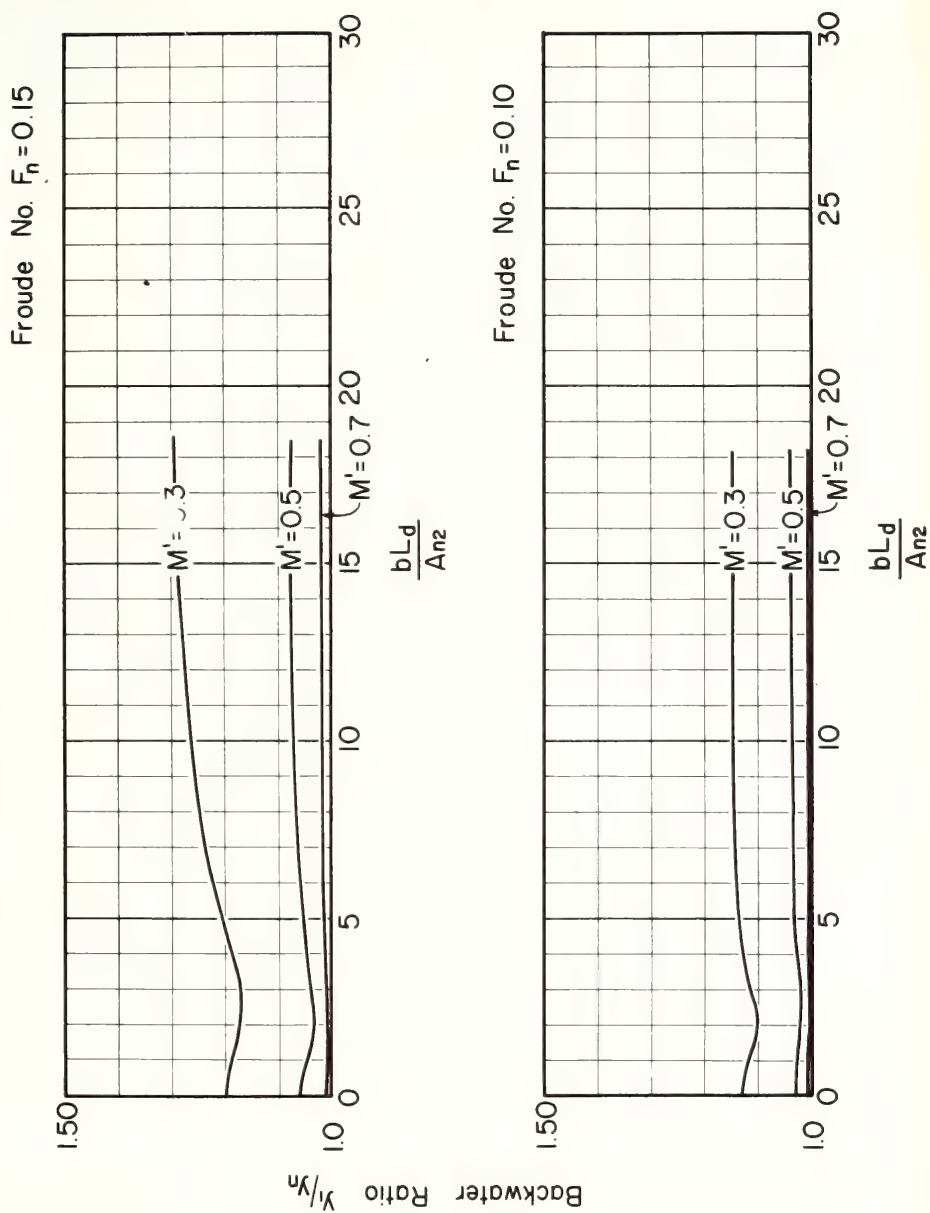


FIG. 7-3-1 BACKWATER RATIO FOR DUAL PARALLEL BRIDGES

$F_n = 0.10$ , AND  $0.15$



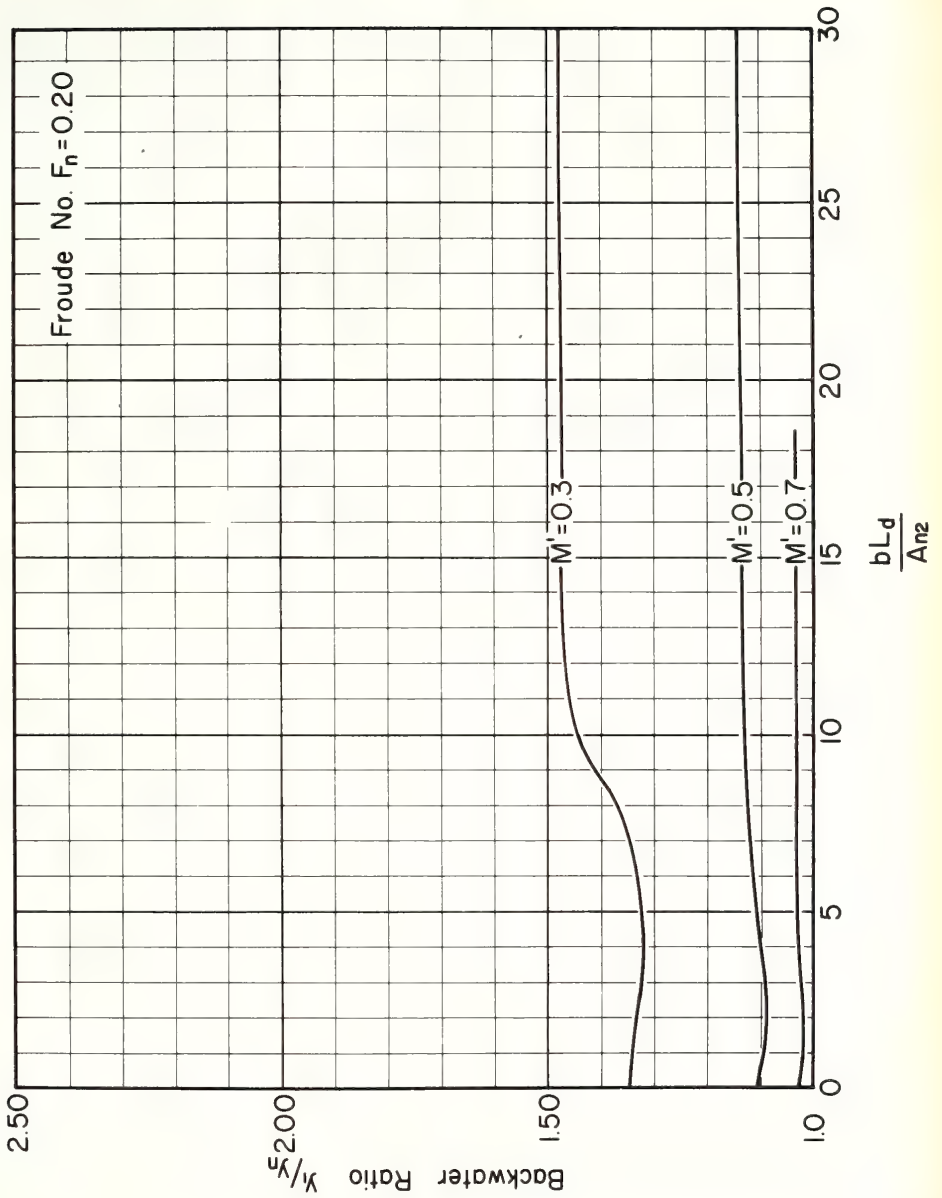


FIG. 7-3-2 BACKWATER RATIO FOR DUAL PARALLEL BRIDGES

$$F_n = 0.20$$



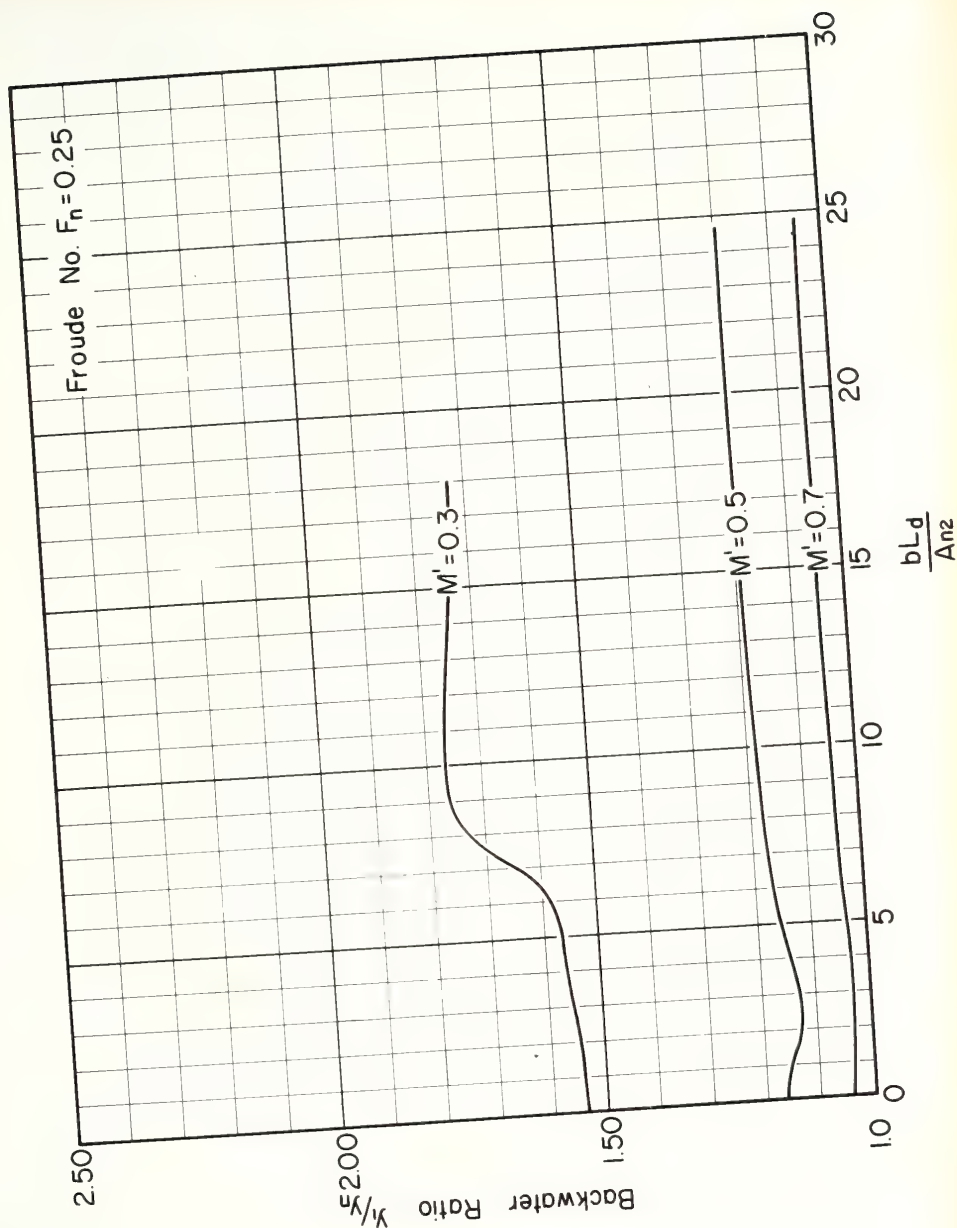


FIG. 7-3-3 BACKWATER RATIO FOR DUAL PARALLEL BRIDGES  
 $F_n = 0.25$



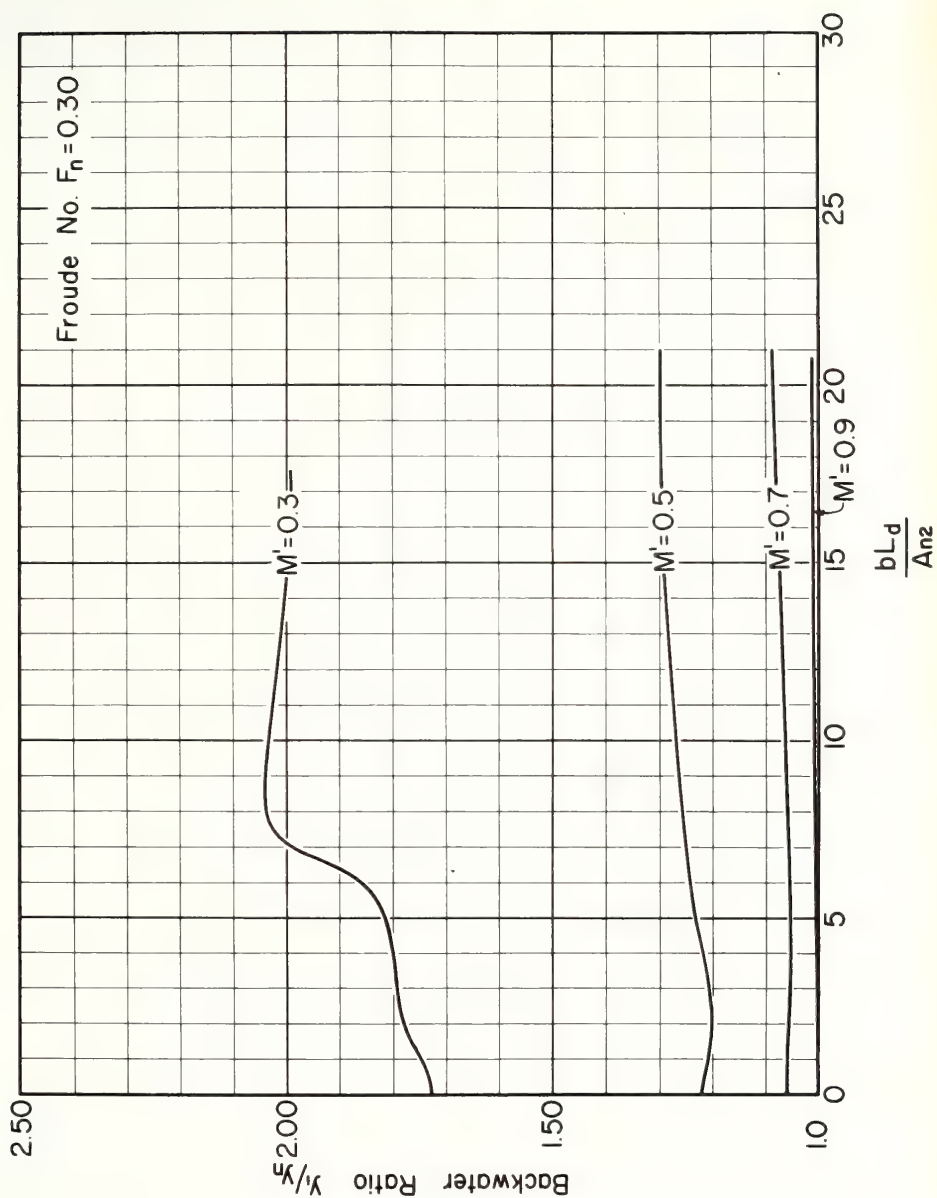


FIG. 7-3-4 BACKWATER RATIO FOR DUAL PARALLEL BRIDGES

$$F_n = 0.30$$





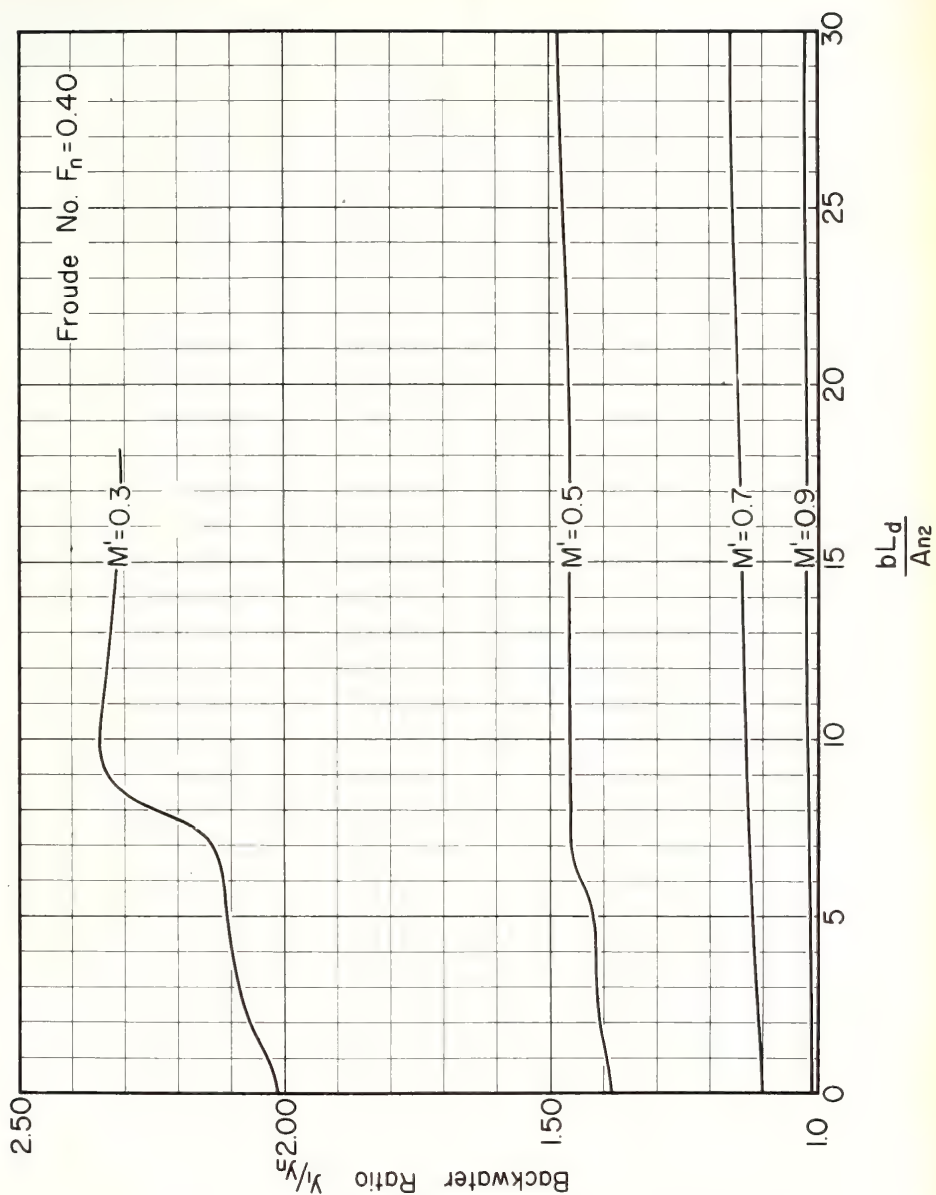


FIG. 7- 3- 5 BACKWATER RATIO FOR DUAL PARALLEL BRIDGES

$$F_n = 0.40$$



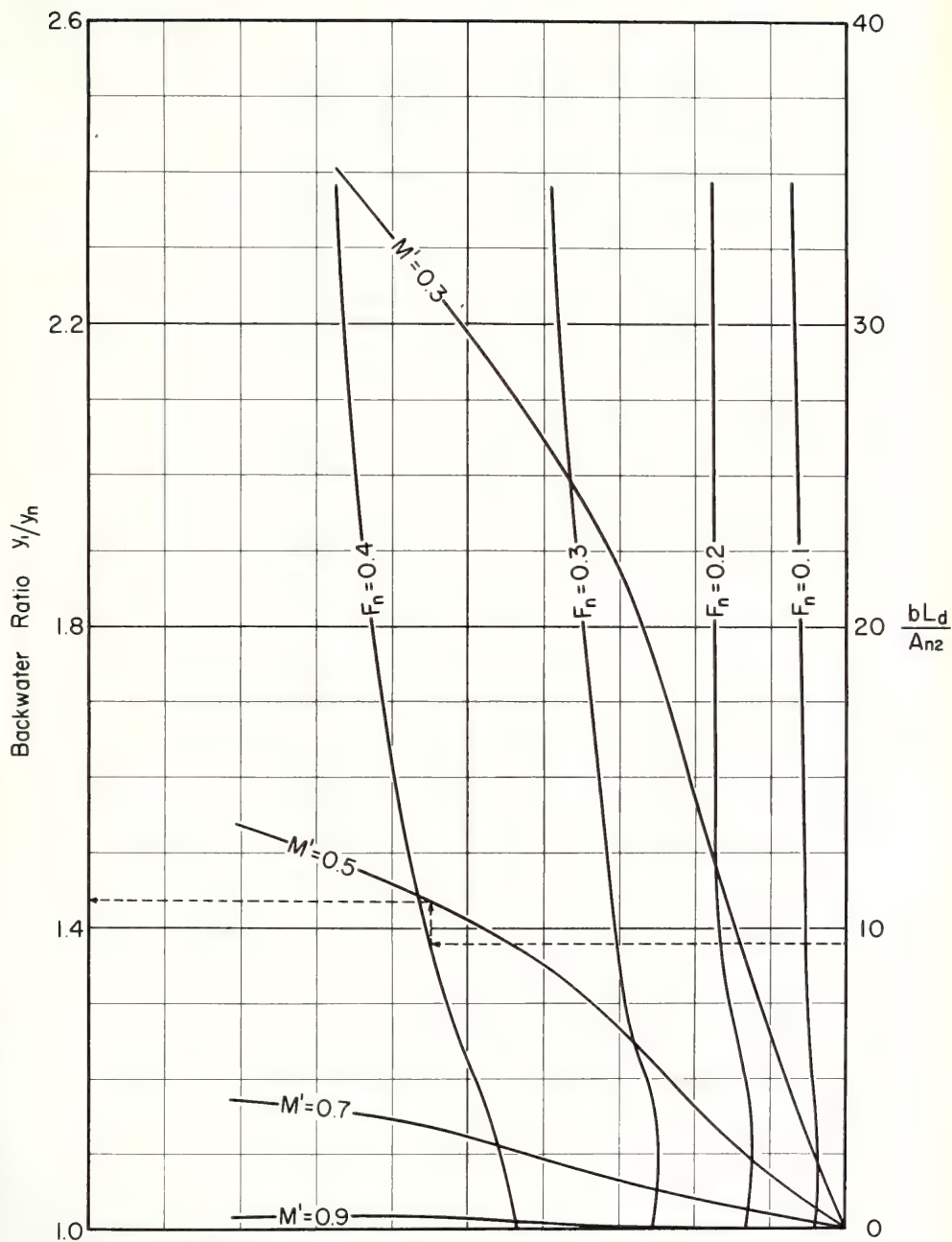


FIG. 7-3-6 BACKWATER RATIO FOR DUAL PARALLEL BRIDGES



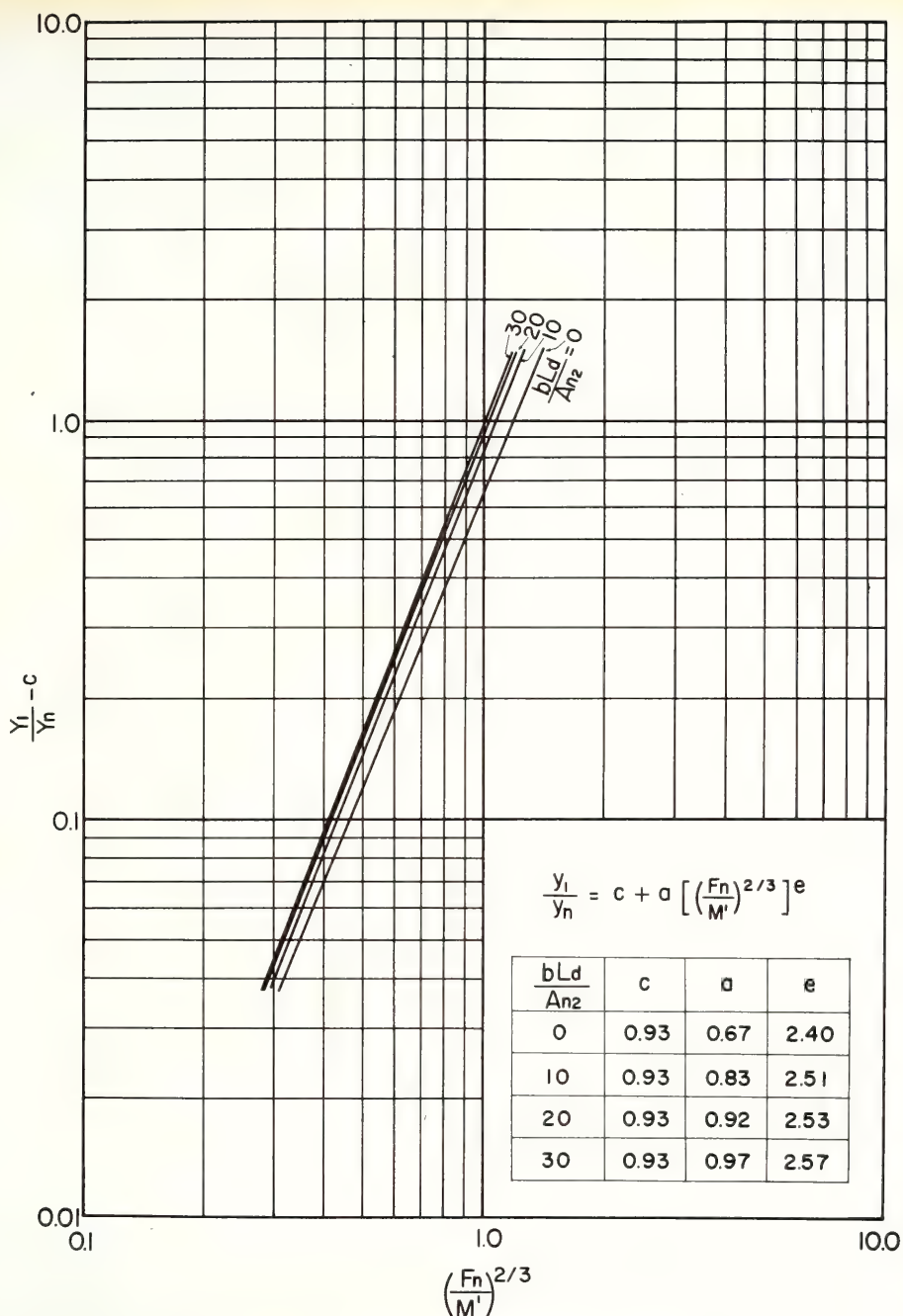


FIG. 7-3-7 - GENERALIZED BACKWATER RATIO FOR  
DUAL PARALLEL BRIDGES



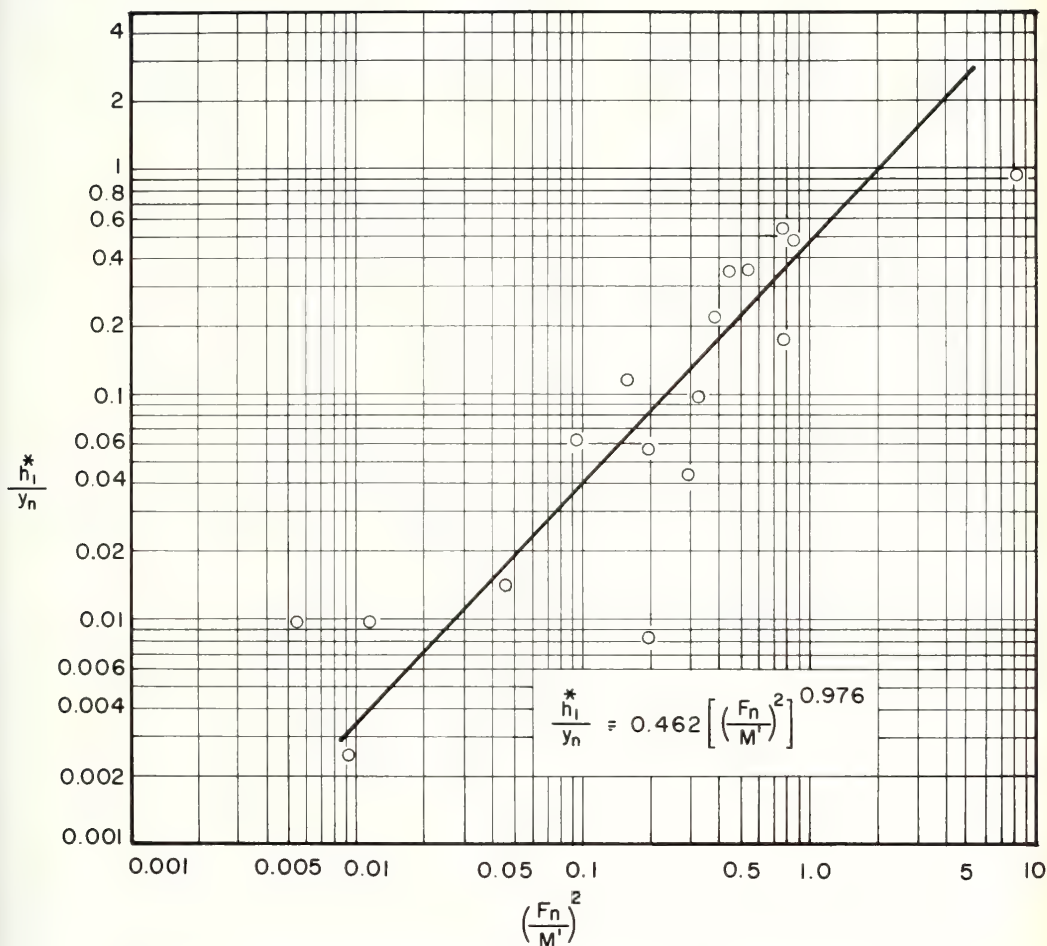


FIGURE 7-3-8 BACKWATER RATIO, GEOMETRY II  
ROUGH BOUNDARY  $\frac{L_d b}{An^2} = 0.00$





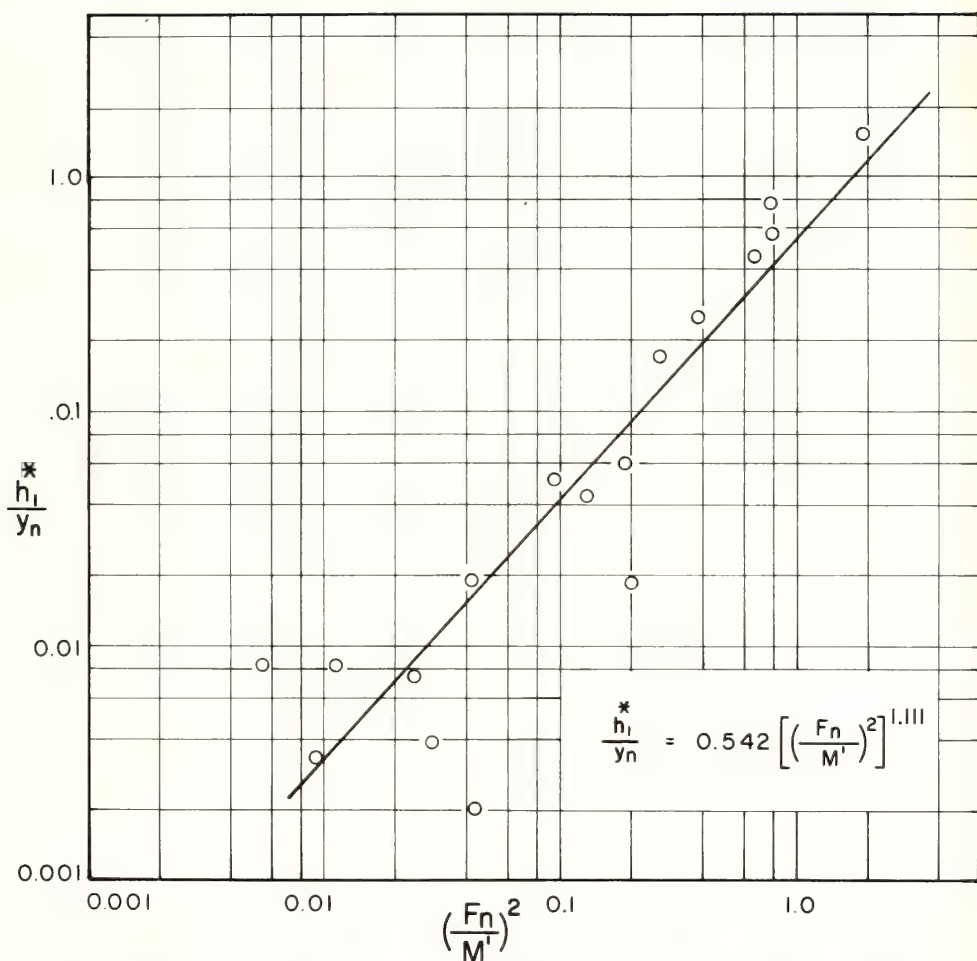


FIGURE 7-3-9 BACKWATER RATIO FOR GEOMETRY II  
ROUGH BOUNDARY  $0 < \frac{L_d b}{An_2} \leq 7.5$



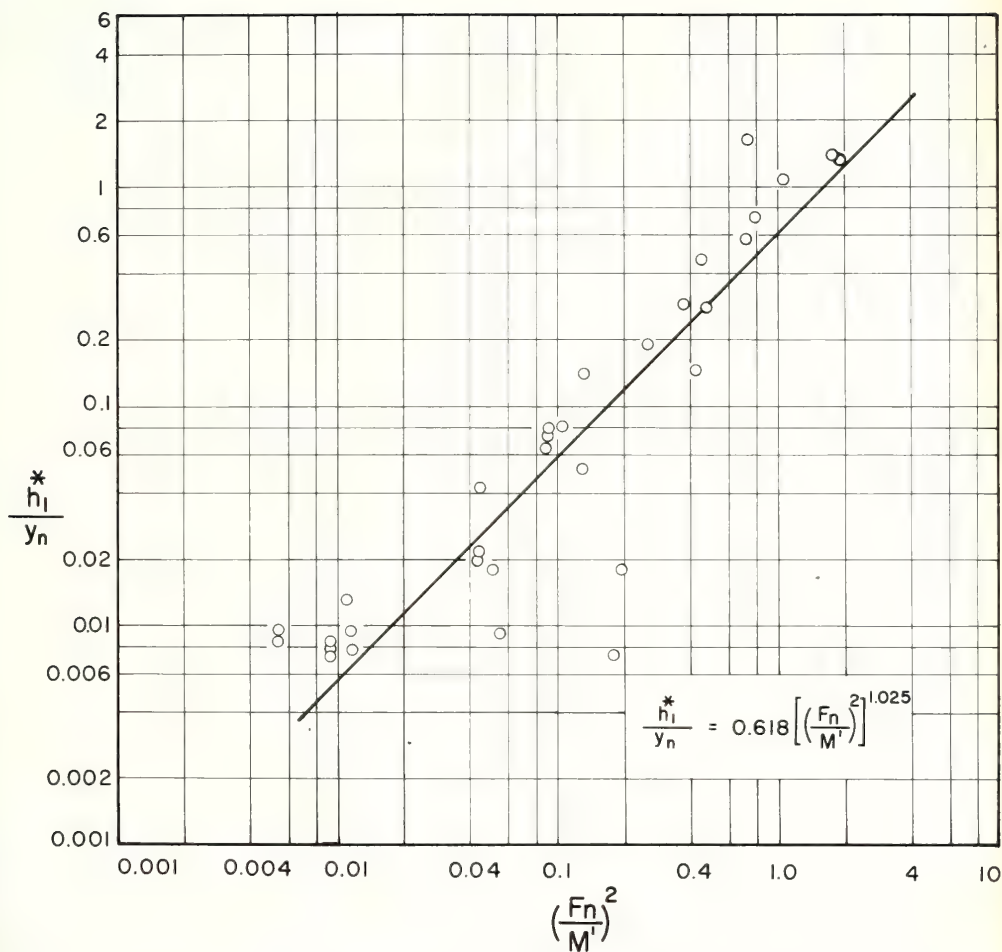


FIGURE 7-3-10 BACKWATER RATIO, GEOMETRY II  
ROUGH BOUNDARY  $\frac{L_{db}}{A_{n2}} = 7.5 - 15$



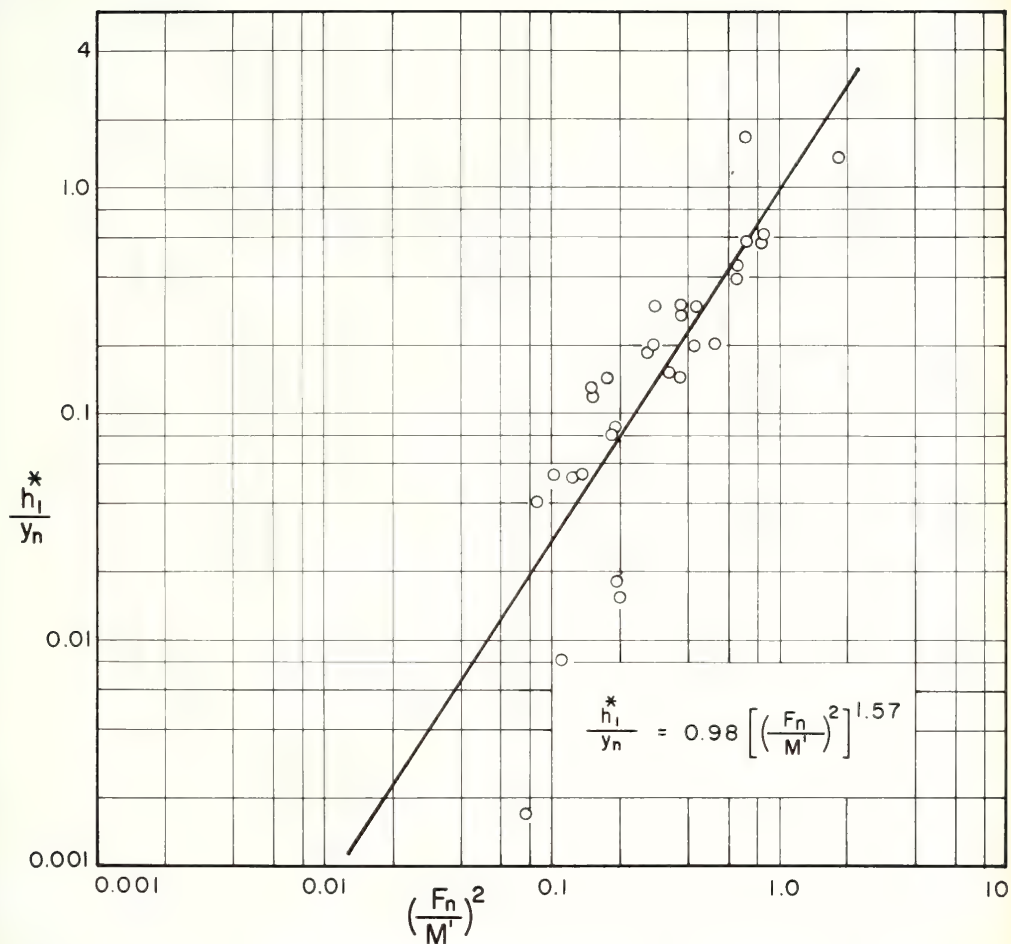


FIGURE 7-3-II BACKWATER RATIO, GEOMETRY II  
ROUGH BOUNDARY  $\frac{L_{db}}{A_{n2}} = 15 - 25$



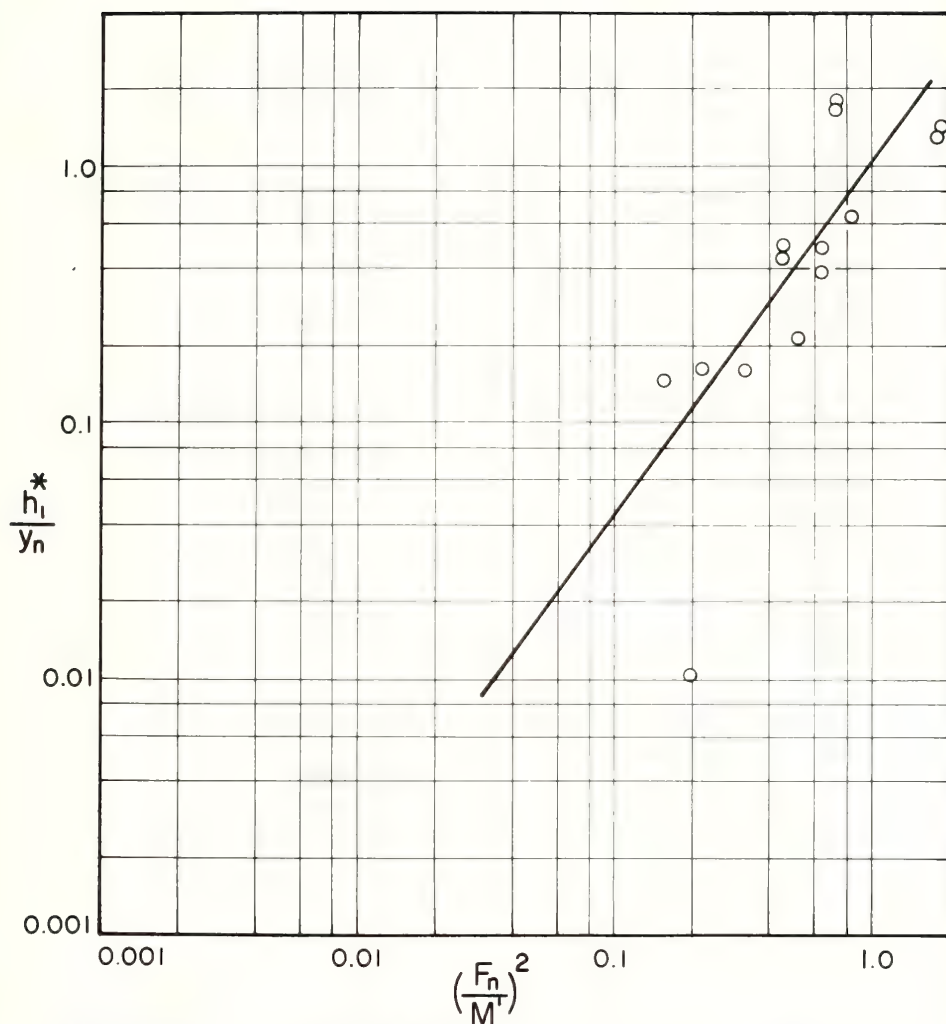


FIGURE 7-3-12 BACKWATER RATIO, GEOMETRY II  
ROUGH BOUNDARY  $\frac{L_{db}}{A_{n2}} = 25-30$





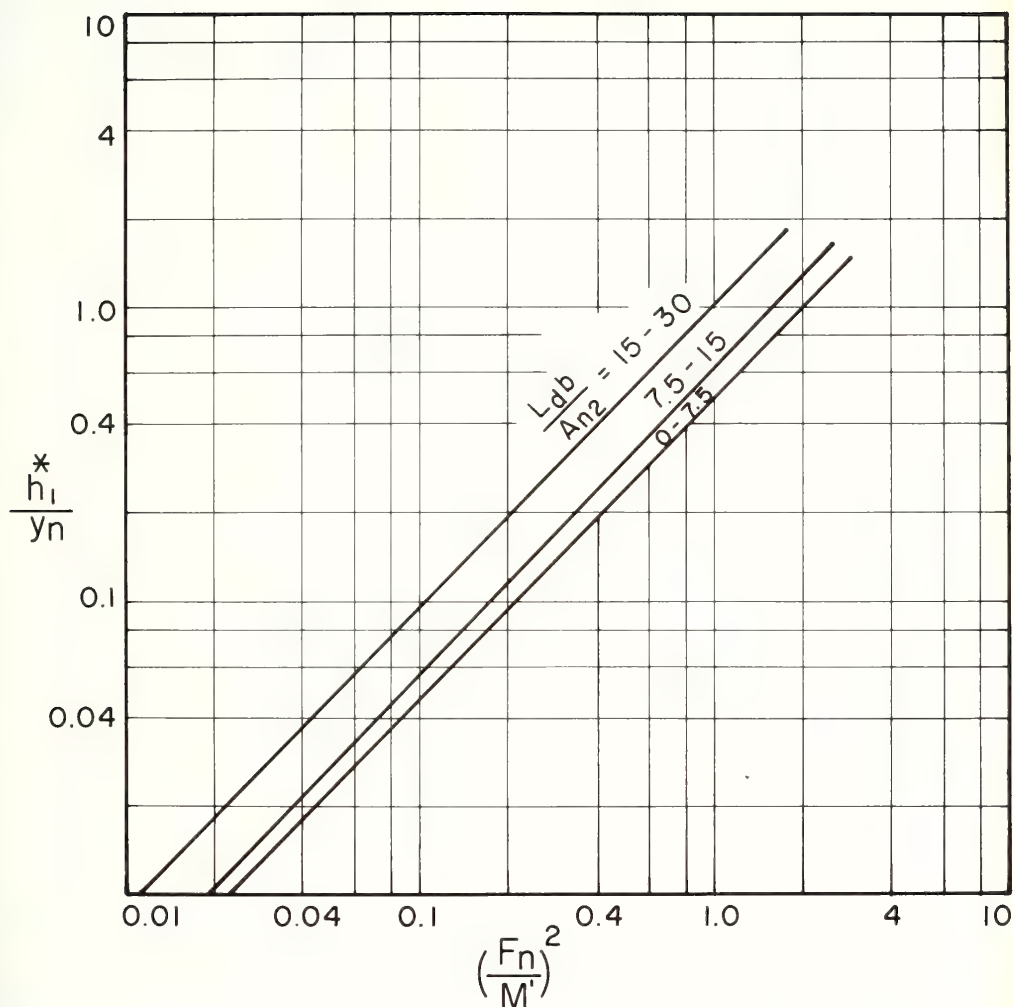


FIGURE 7-3-13 SUMMARY OF BACKWATER  
RATIO, GEOMETRY II  
ROUGH BOUNDARY







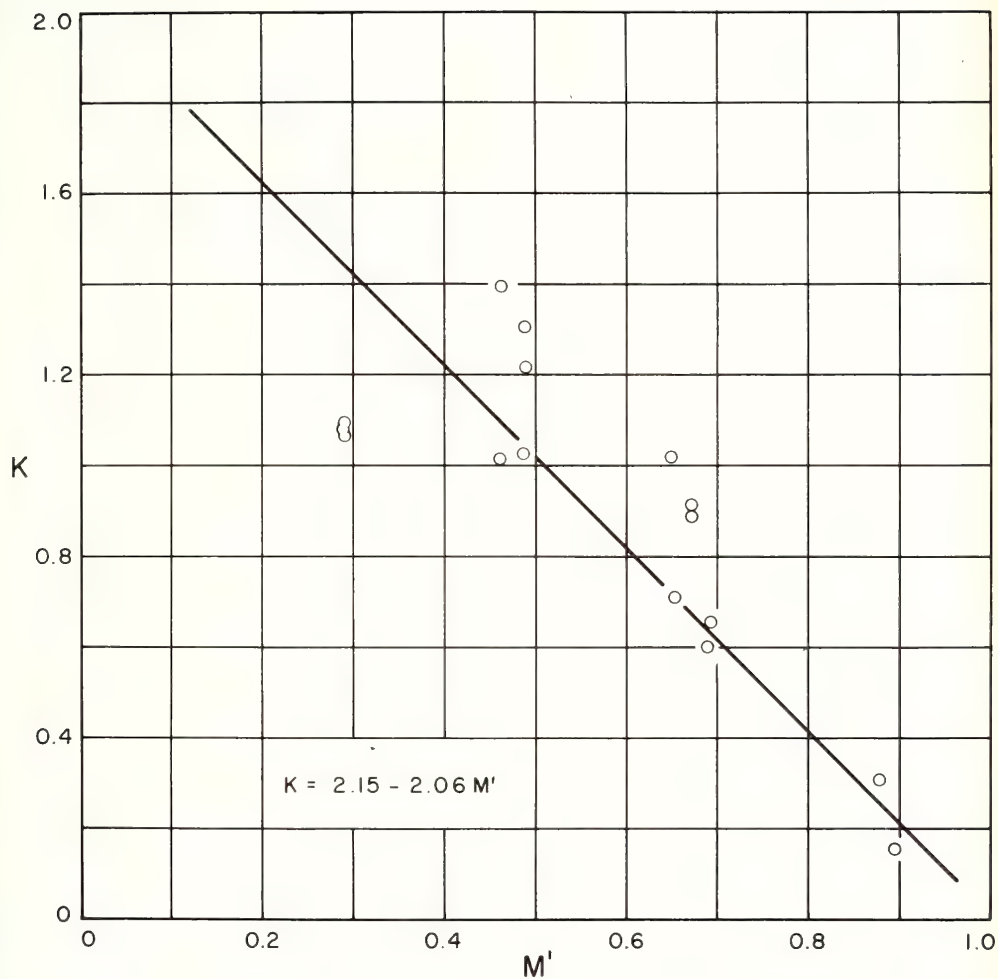


FIGURE 7-3-15 HEAD LOSS COEFFICIENT, GEOMETRY II  
 ROUGH BOUNDARY  $\frac{L_{db}}{An_2} > 0 \leq 7.5$









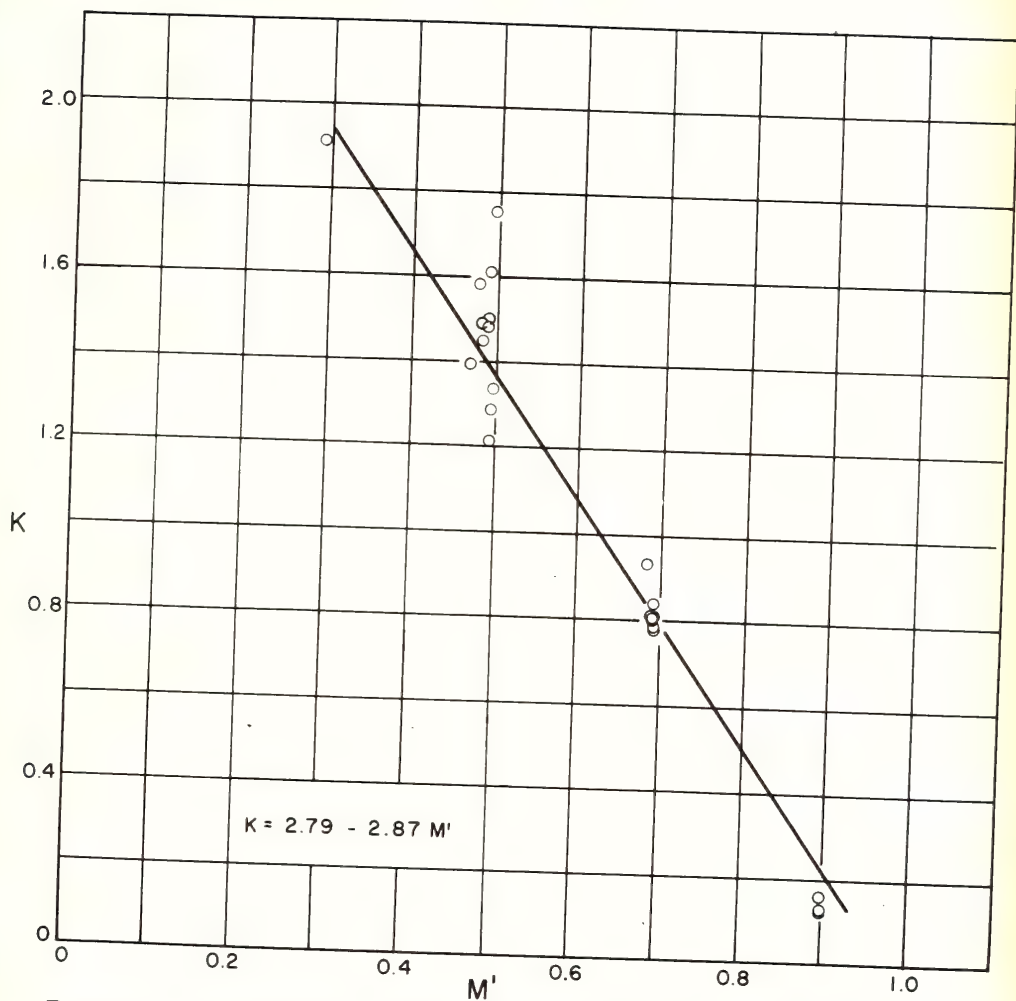


FIGURE 7-3-17 HEAD LOSS COEFFICIENT, GEOMETRY II  
ROUGH BOUNDARY  $\frac{L_{db}}{An_2} = 15 - 25$



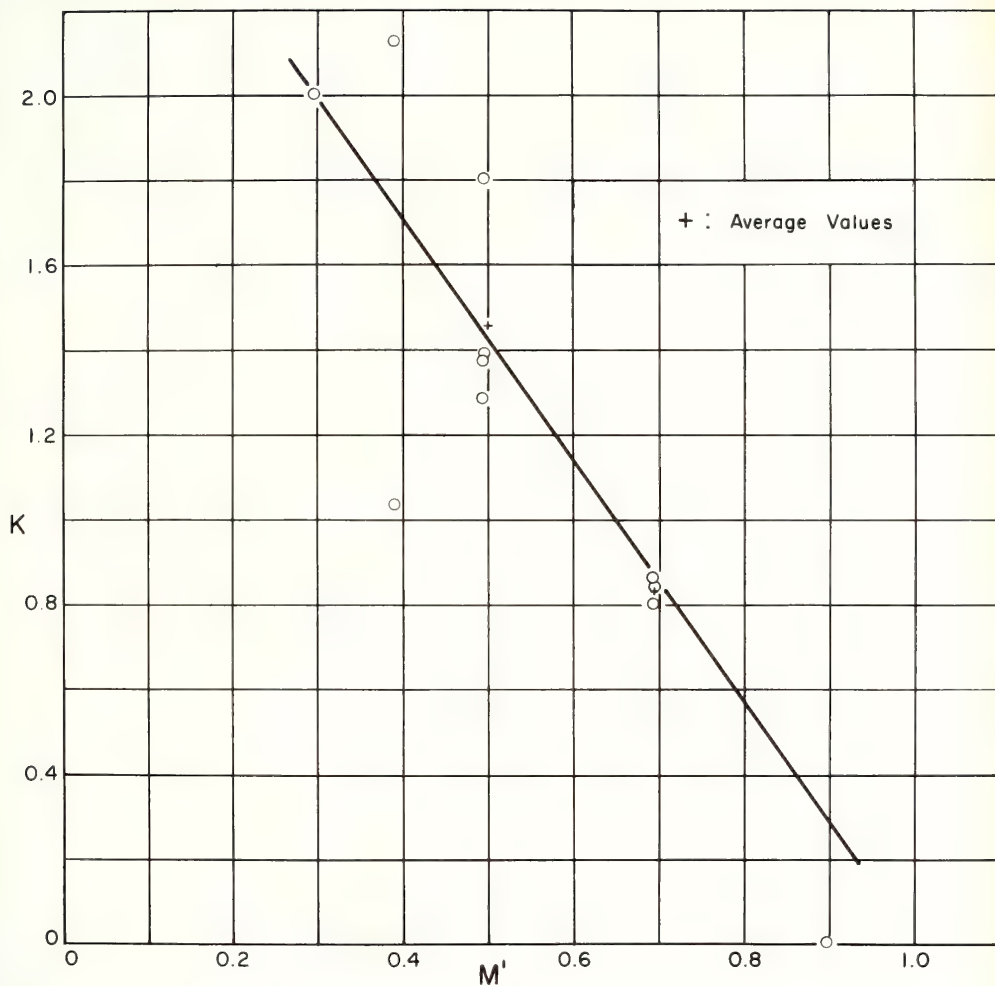


FIGURE 7-3-18 HEAD LOSS COEFFICIENT, GEOMETRY II  
 ROUGH BOUNDARY  $\frac{L_d b}{A_{n2}} = 25 - 30$



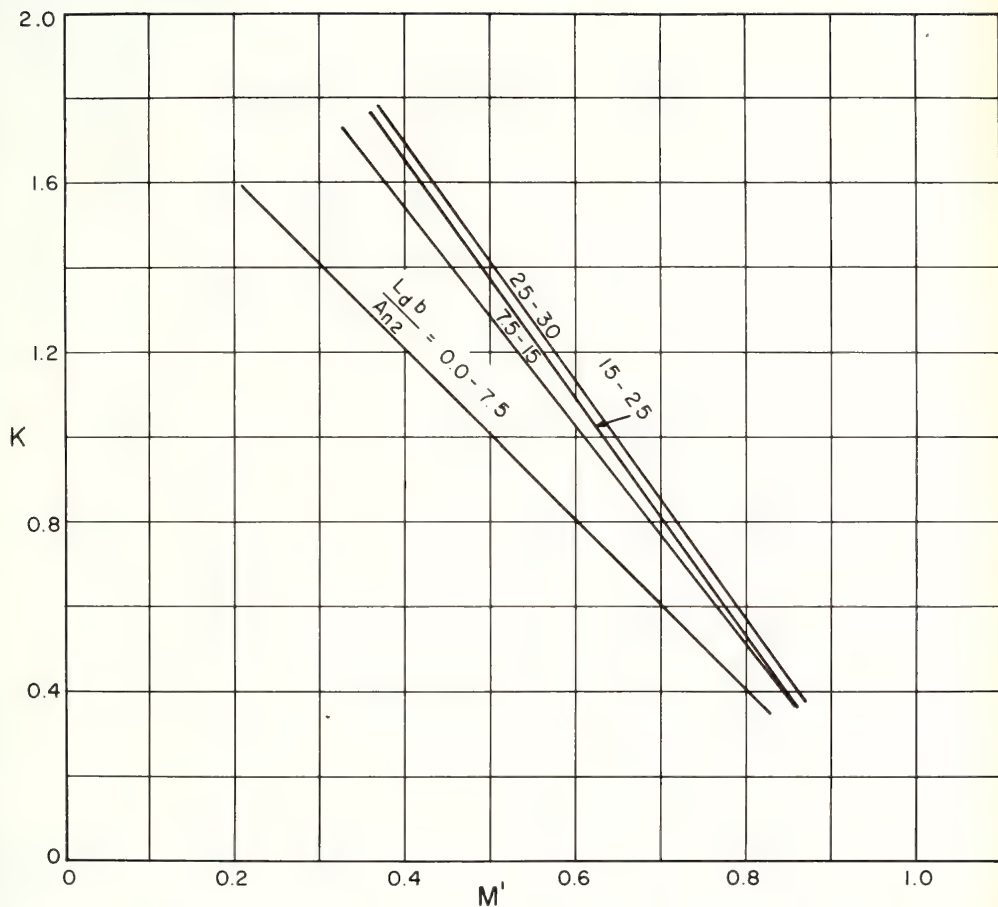


FIGURE 7-3-19 SUMMARY OF HEAD LOSS COEFFICIENTS, GEOMETRY II, ROUGH BOUNDARIES



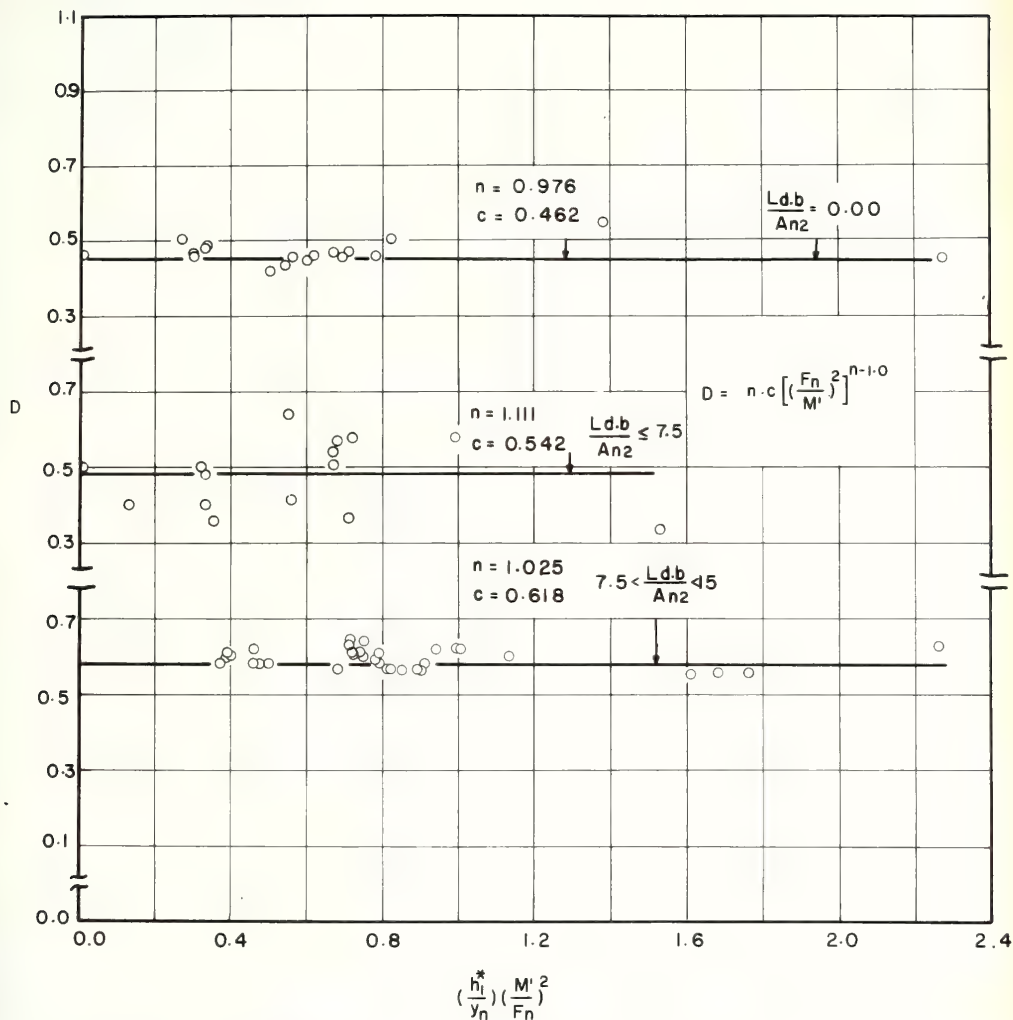


FIGURE 7-3-20 BACKWATER RATIO COEFFICIENT GEOMETRY II

ROUGH BOUNDARY





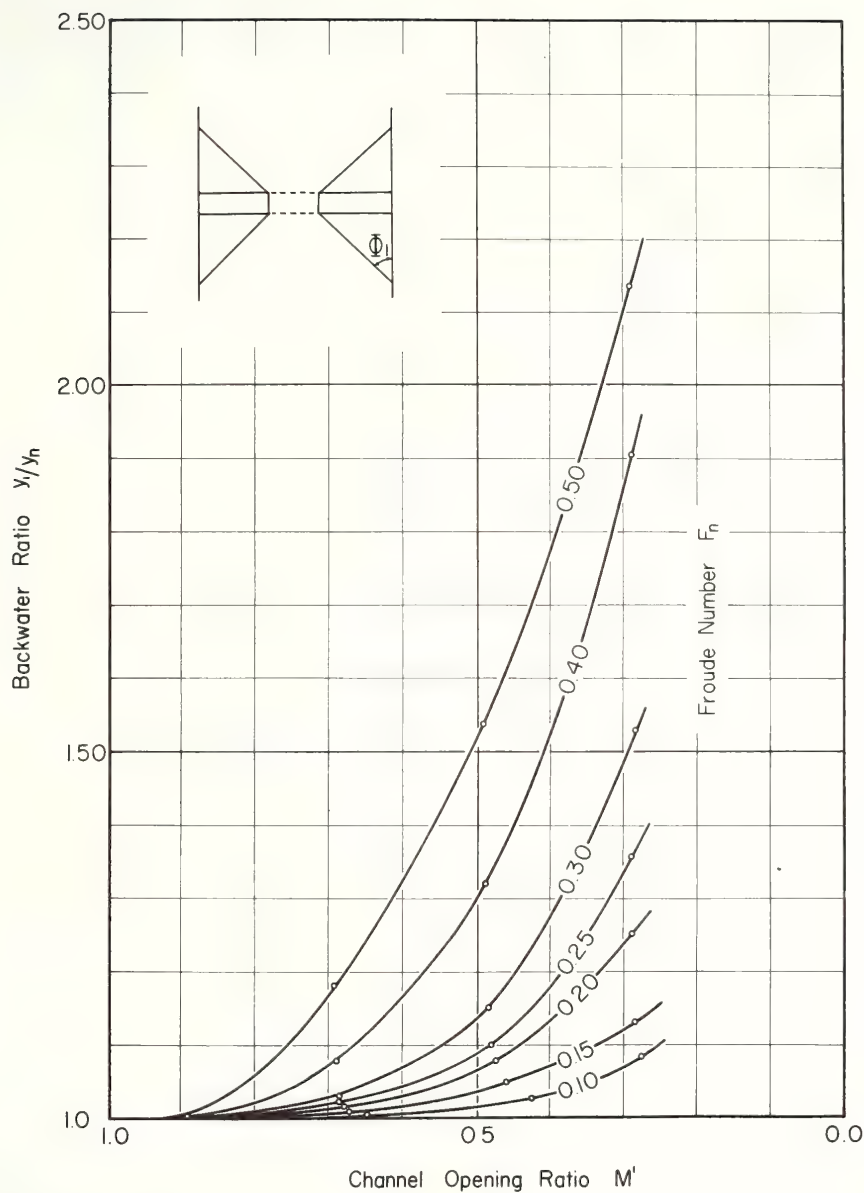


FIG. 7-4-1 BACKWATER RATIO FOR ARCH BRIDGES  
WITH WINGWALLS  $\Phi_1 = 30^\circ$



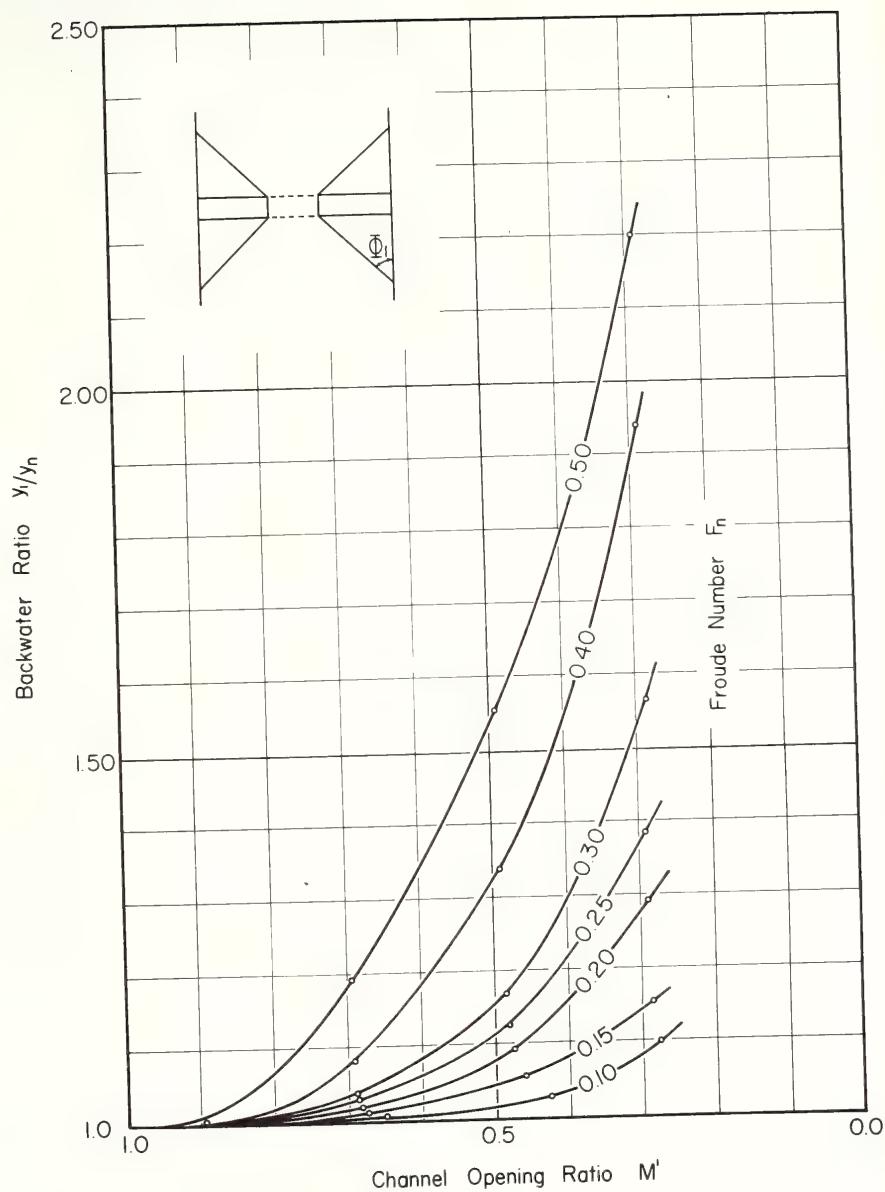


FIG. 7-4-2 BACKWATER RATIO FOR ARCH BRIDGES  
WITH WINGWALLS  $\Phi_1 = 45^\circ$



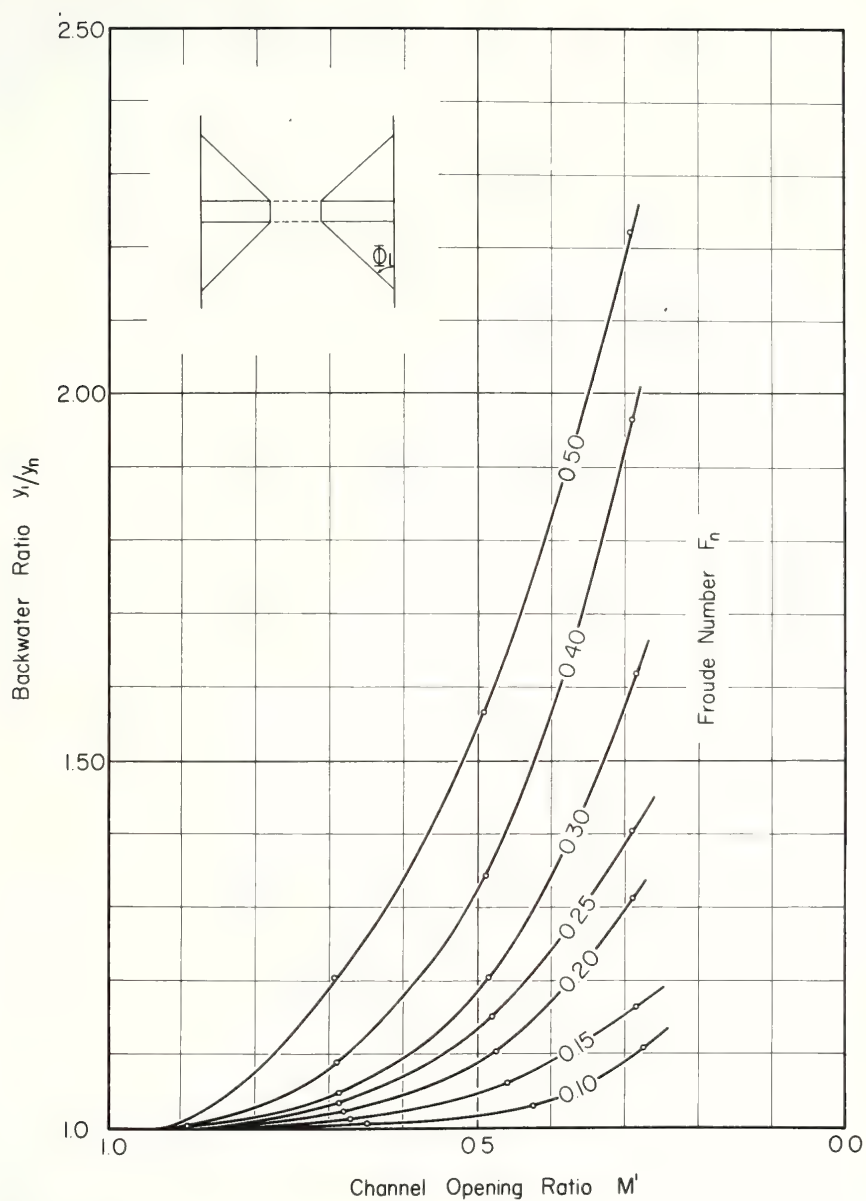


FIG. 7-4-3 BACKWATER RATIO FOR ARCH BRIDGES  
WITH WINGWALLS  $\Phi_1 = 60^\circ$



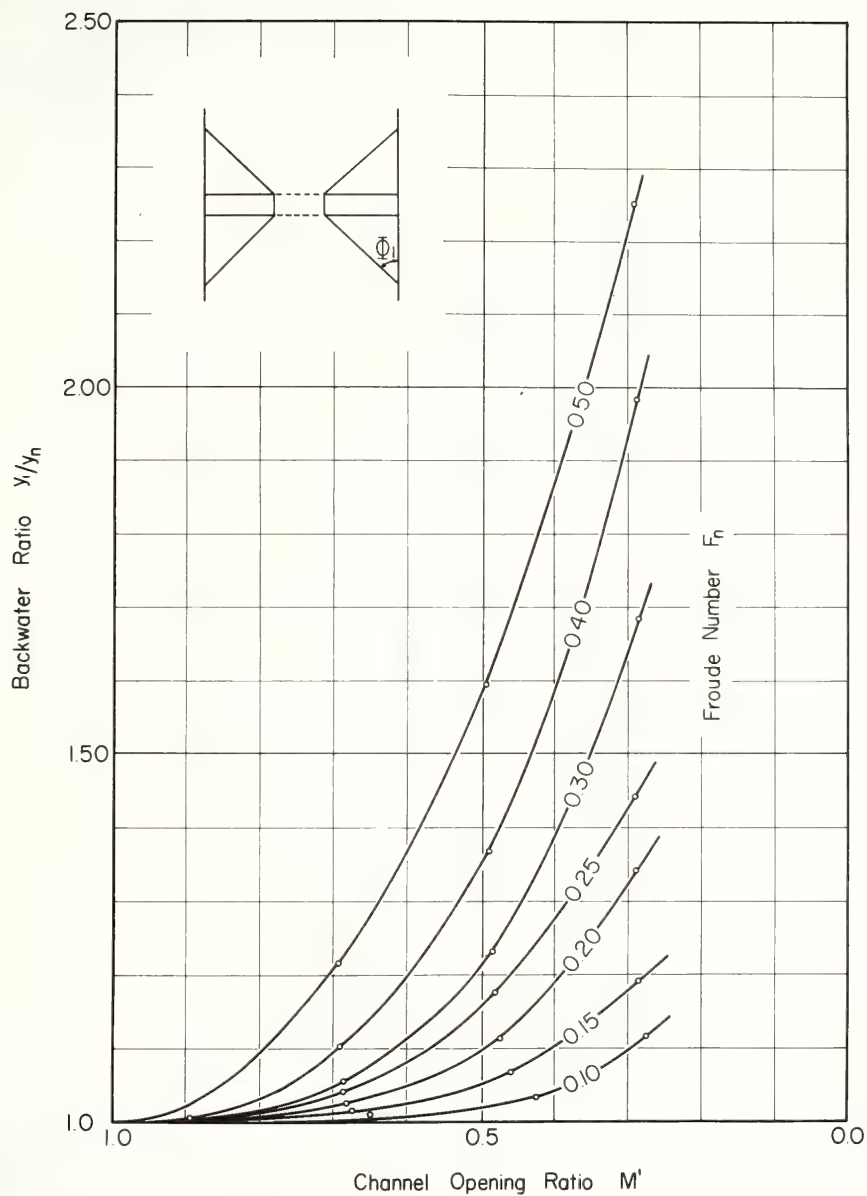


FIG. 7-4-4 BACKWATER RATIO FOR ARCH BRIDGES  
WITH WINGWALLS  $\Phi_1 = 90^\circ$





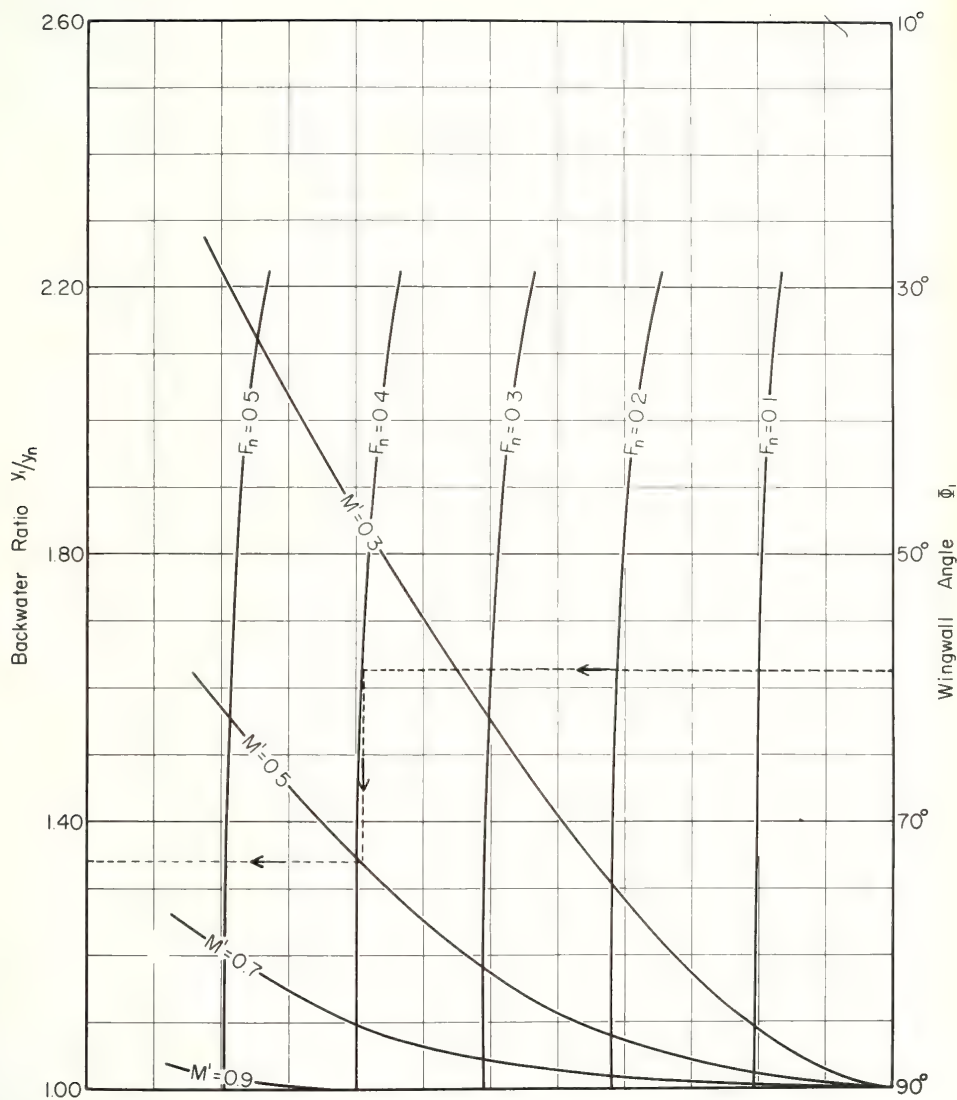


FIG.7-4-5 BACKWATER RATIO FOR ARCH BRIDGES WITH WINGWALLS



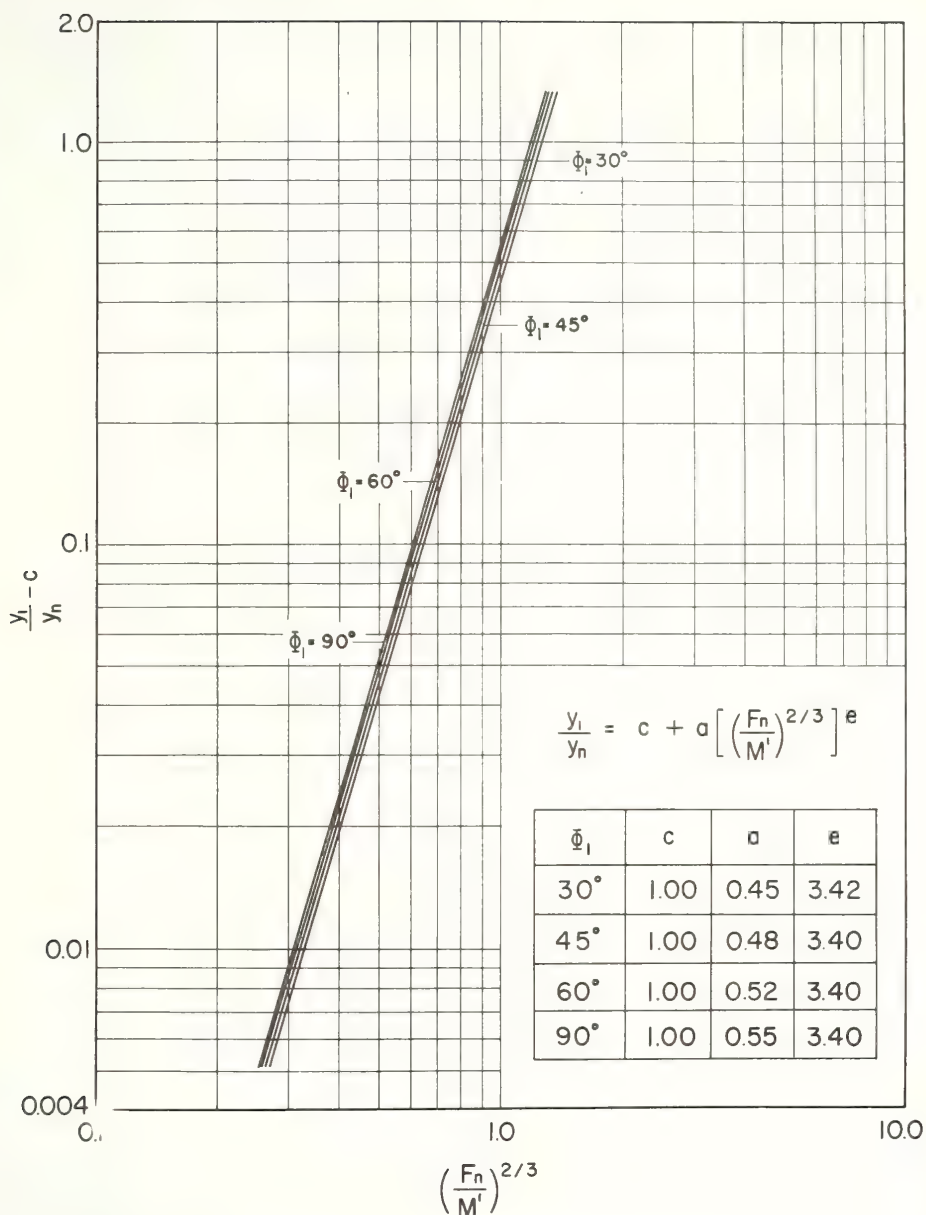


FIG. 7-4-6 - GENERALIZED BACKWATER RATIO FOR  
ARCH BRIDGES WITH WINGWALLS



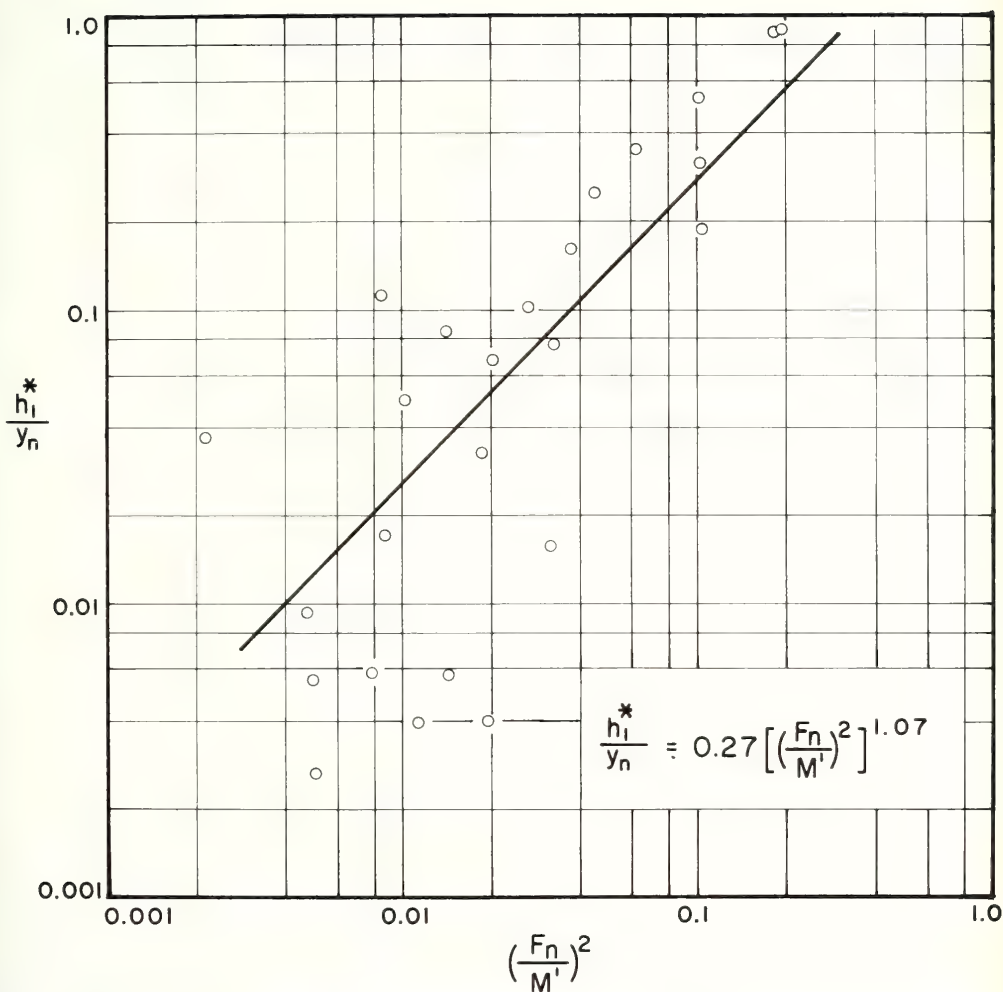


FIGURE 7-4-7 BACKWATER RATIO, GEOMETRY III  
ROUGH BOUNDARY  $\Phi_1 = 30^\circ$



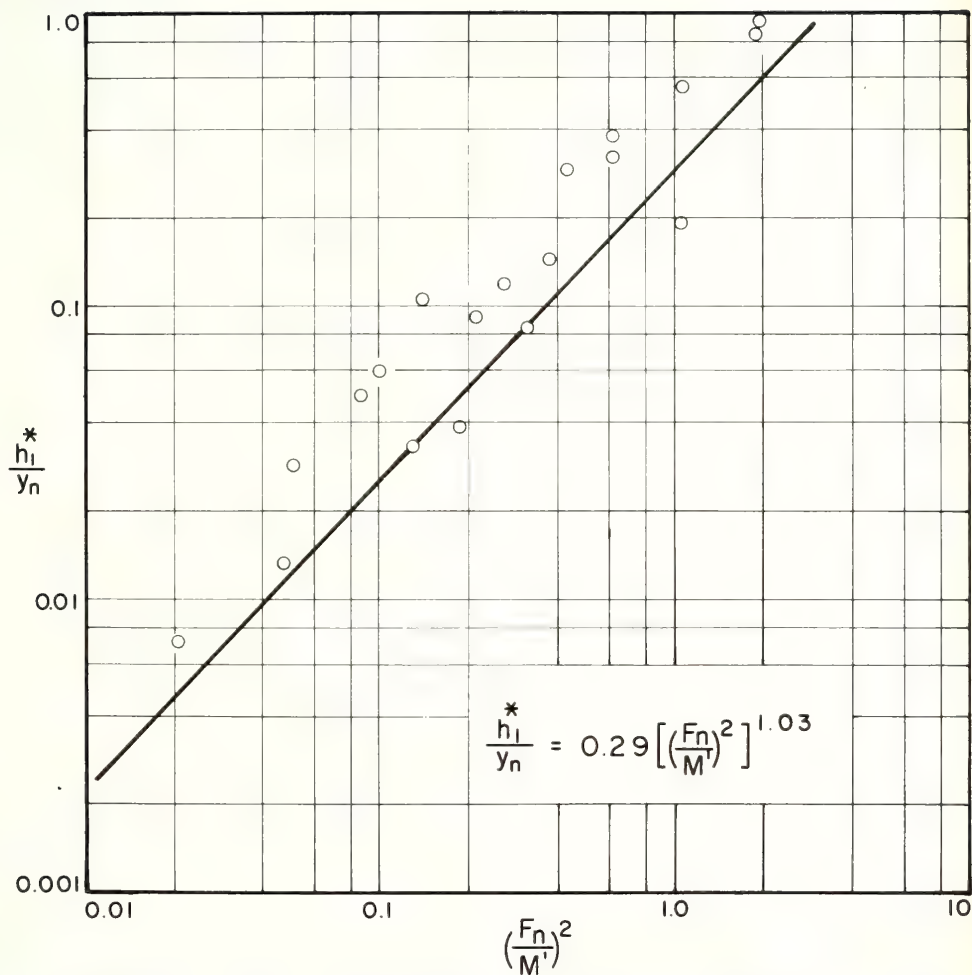


FIGURE 7-4-8 BACKWATER RATIO, GEOMETRY III  
ROUGH BOUNDARY  $\Phi_1 = 45^\circ$





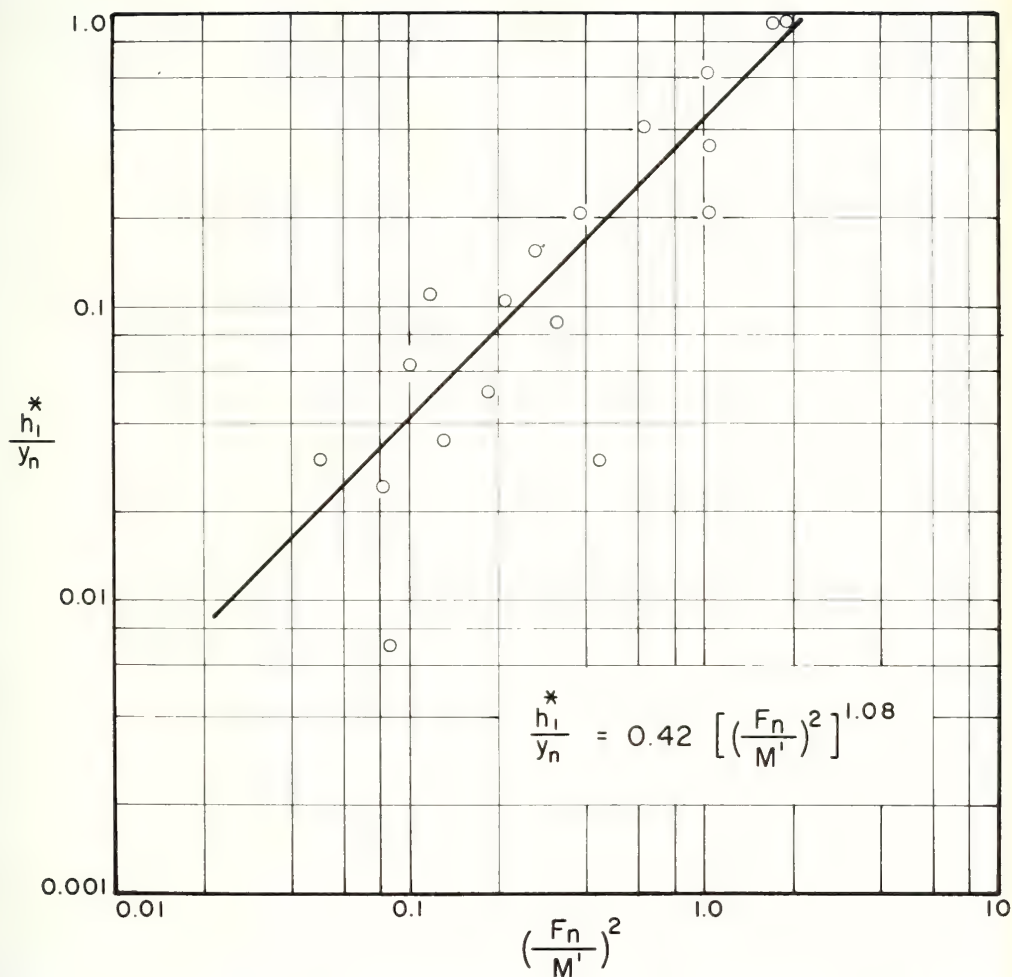


FIGURE 7-4-9 BACKWATER RATIO, GEOMETRY III  
ROUGH BOUNDARY  $\Phi_1 = 60^\circ$



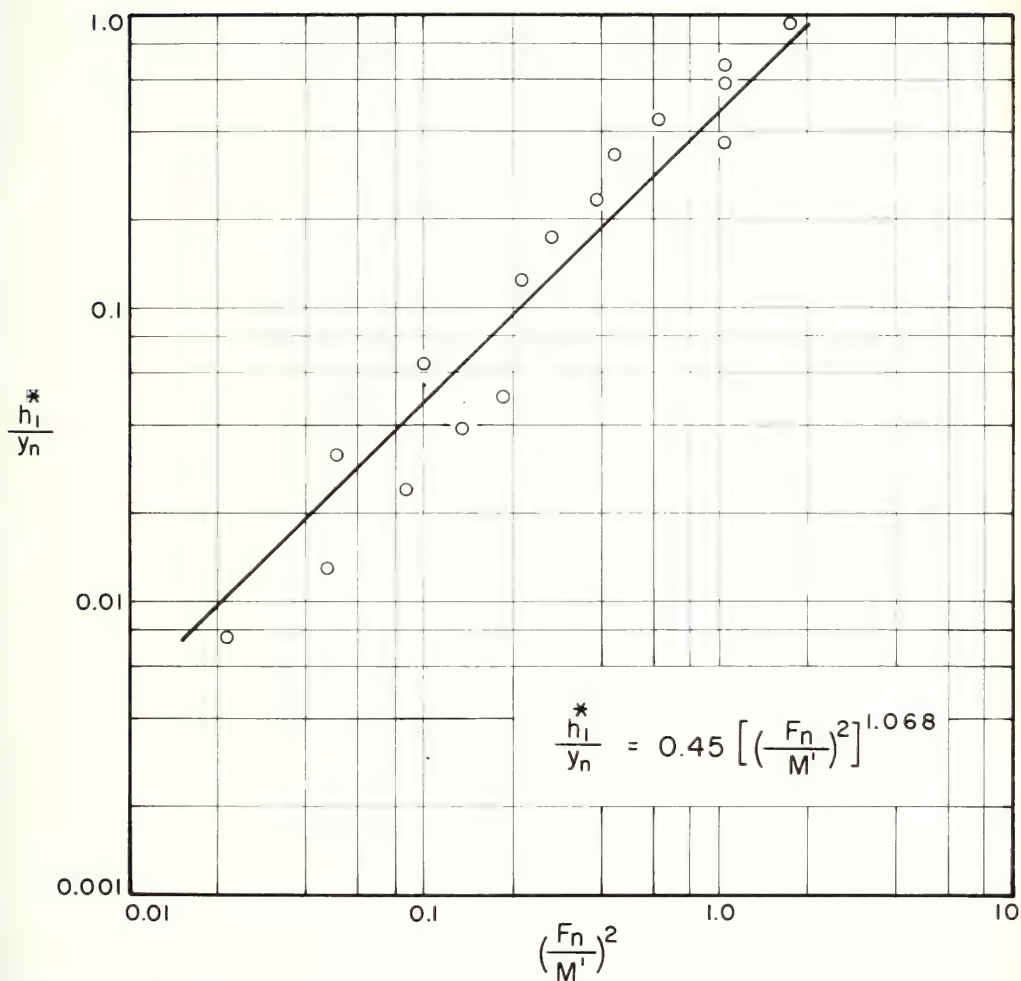


FIGURE 7-4-10 BACKWATER RATIO, GEOMETRY III  
ROUGH BOUNDARY  $\Phi_1 = 90^\circ$



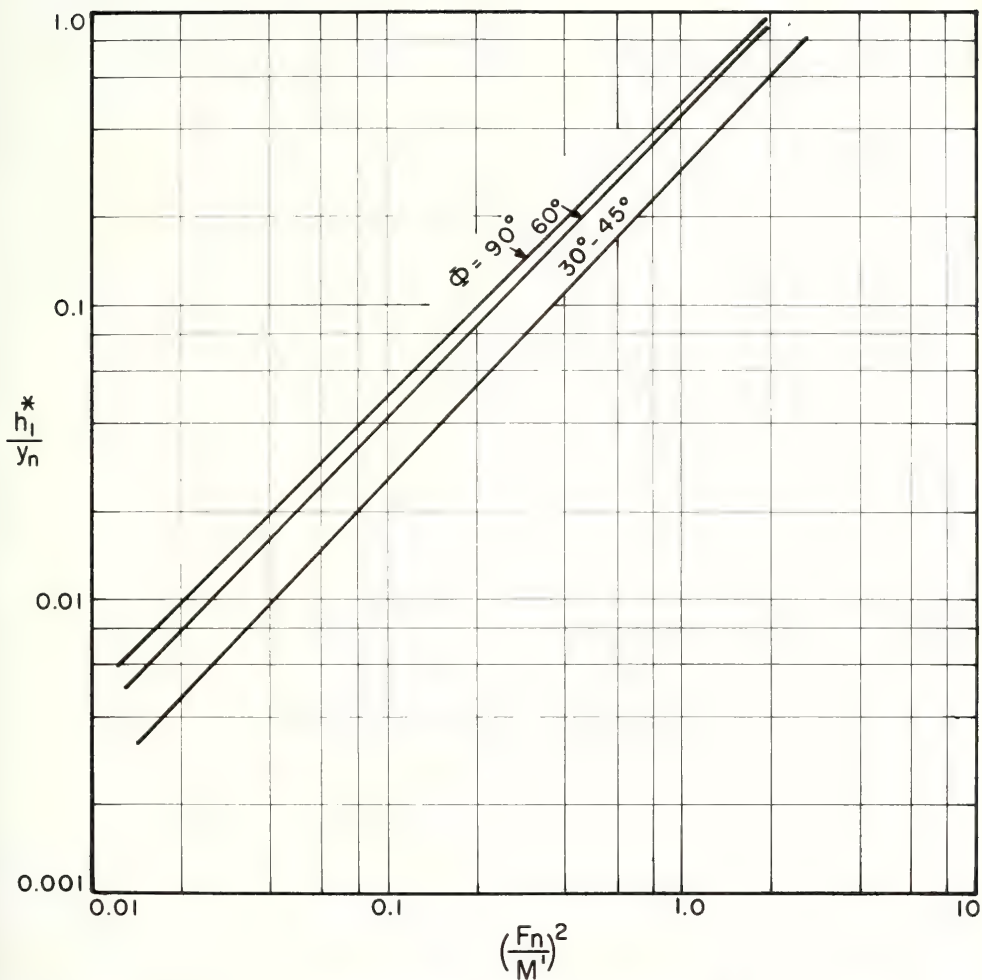


FIGURE 7-4-II SUMMARY OF BACKWATER RATIO, GEOMETRY III, ROUGH BOUNDARY



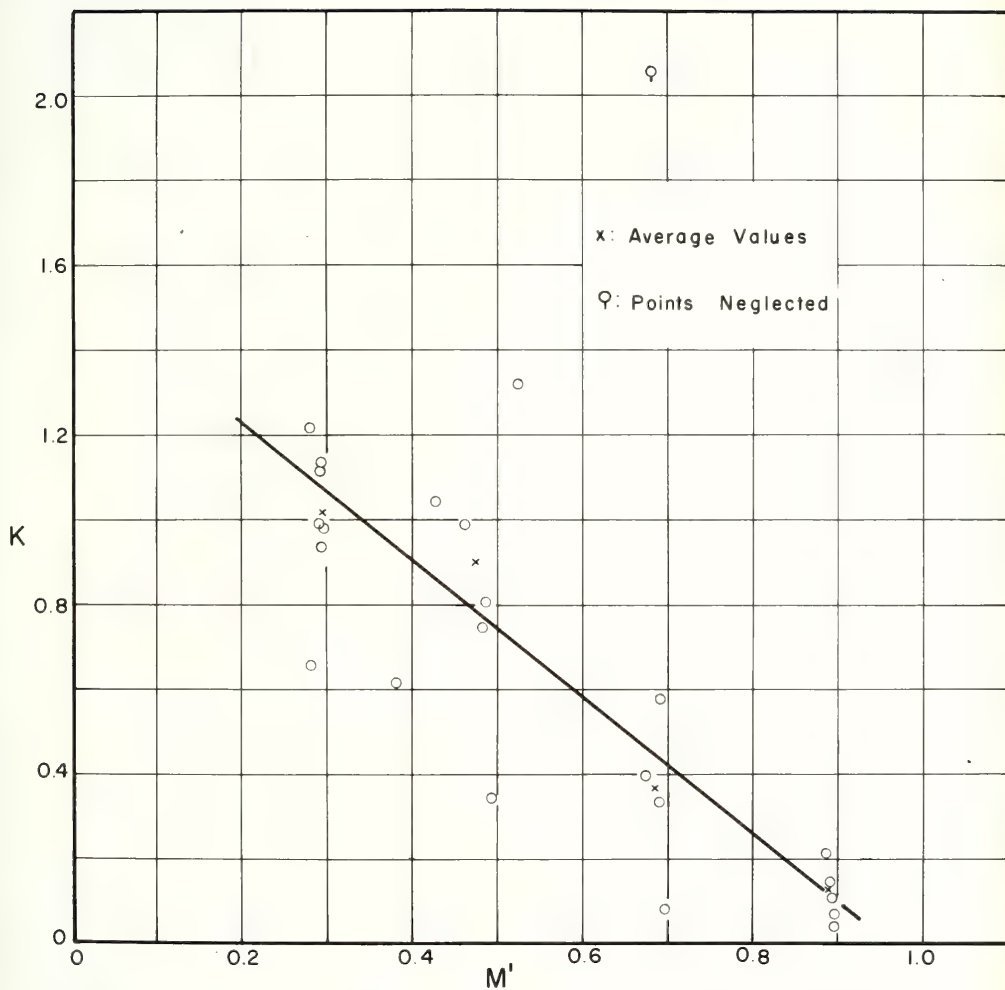


FIGURE 7-4-12 HEAD LOSS COEFFICIENT, GEOMETRY III  
ROUGH BOUNDARY  $\phi_1 = 30^\circ$





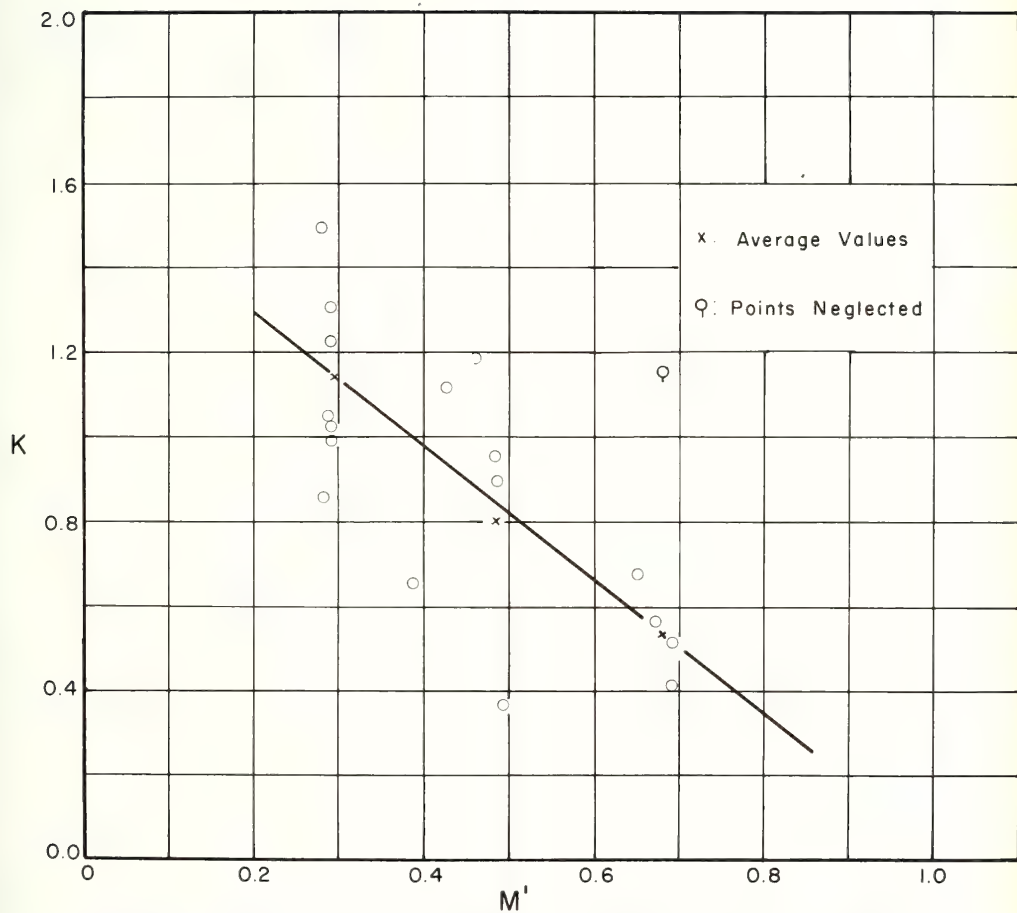


FIGURE 7-4-13 HEAD LOSS COEFFICIENT, GOMETRY III  
ROUGH BOUNDARY  $\Phi_1 = 45^\circ$



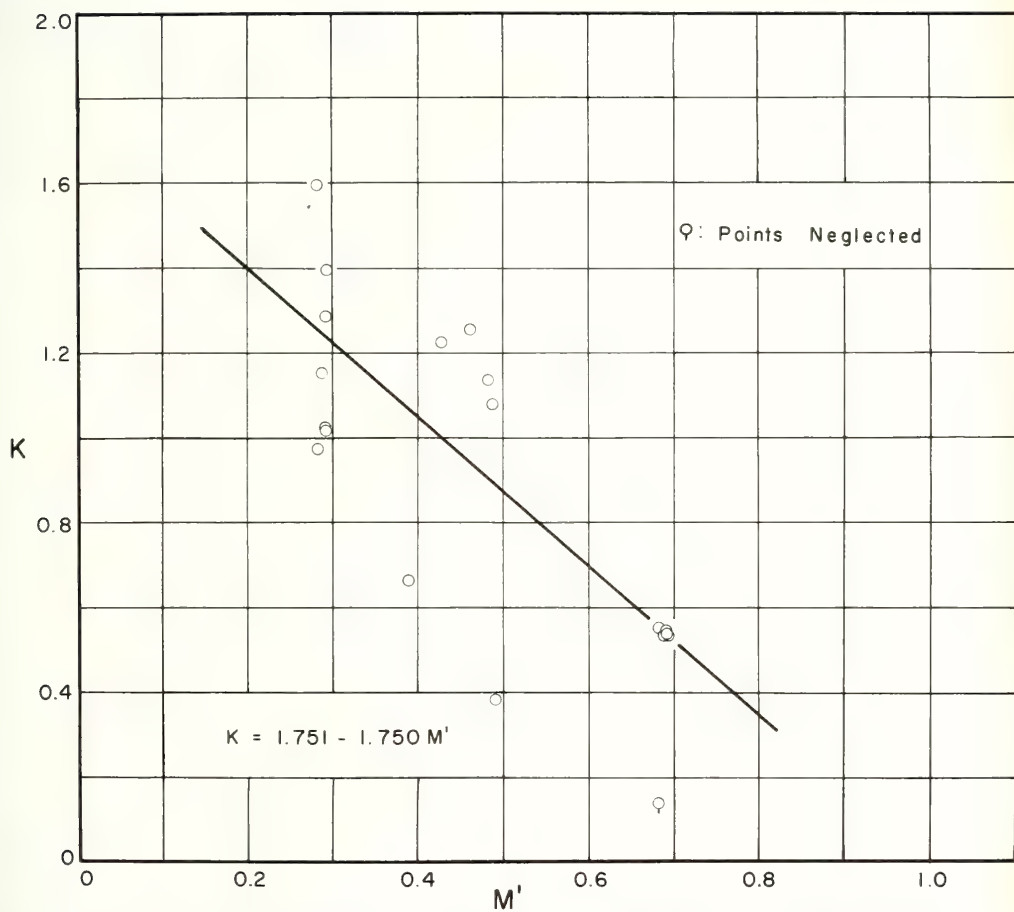


FIGURE 7-4-14 HEAD LOSS COEFFICIENT, GEOMETRY III  
ROUGH BOUNDARY  $\Phi_1 = 60^\circ$



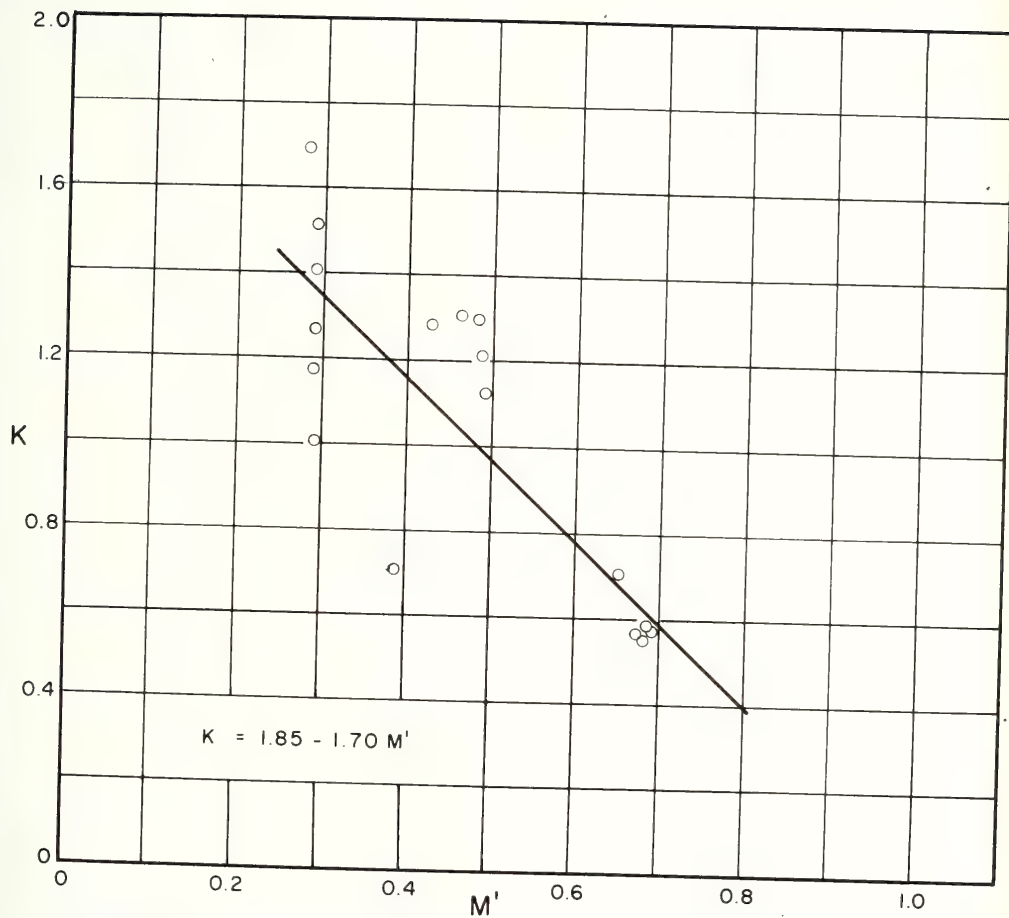


FIGURE 7-4-15 HEAD LOSS COEFFICIENT, GEOMETRY III  
ROUGH BOUNDARY  $\Phi_1 = 90^\circ$



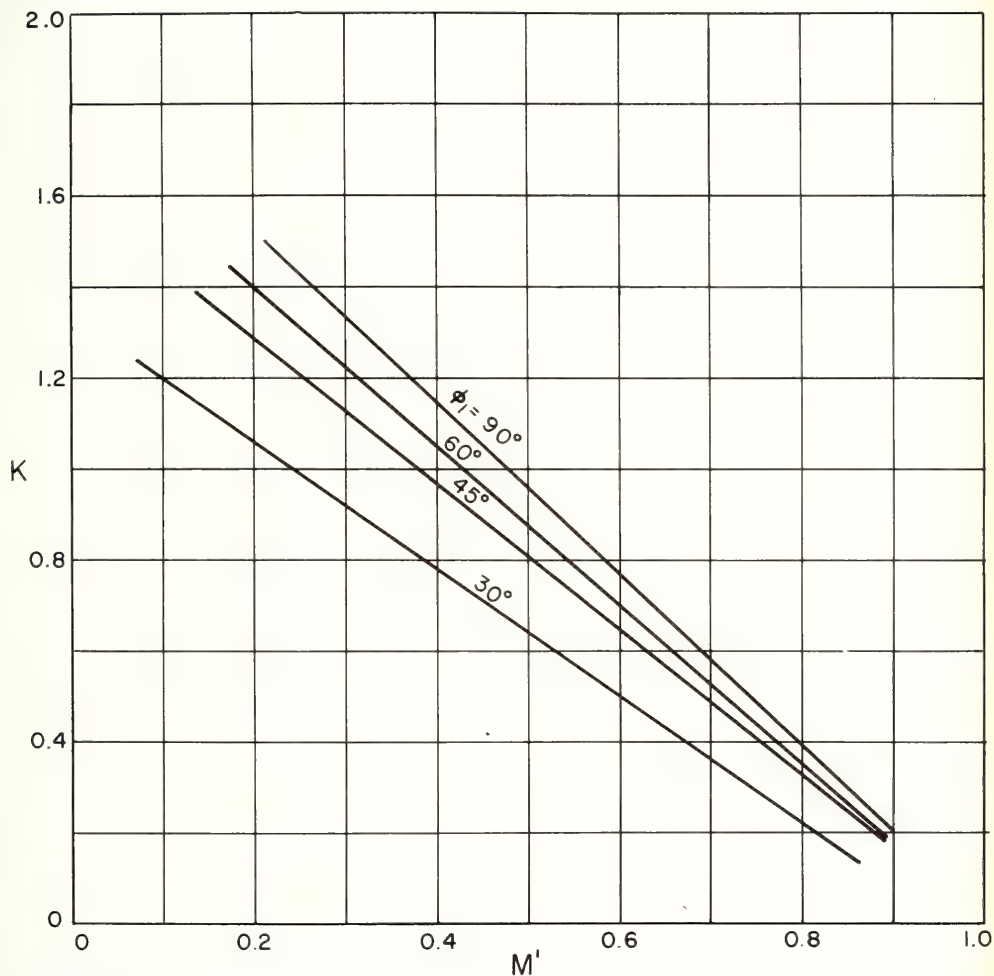


FIGURE 7-4-16 SUMMARY OF HEAD LOSS COEFFICIENTS  
GEOMETRY III, ROUGH BOUNDARIES





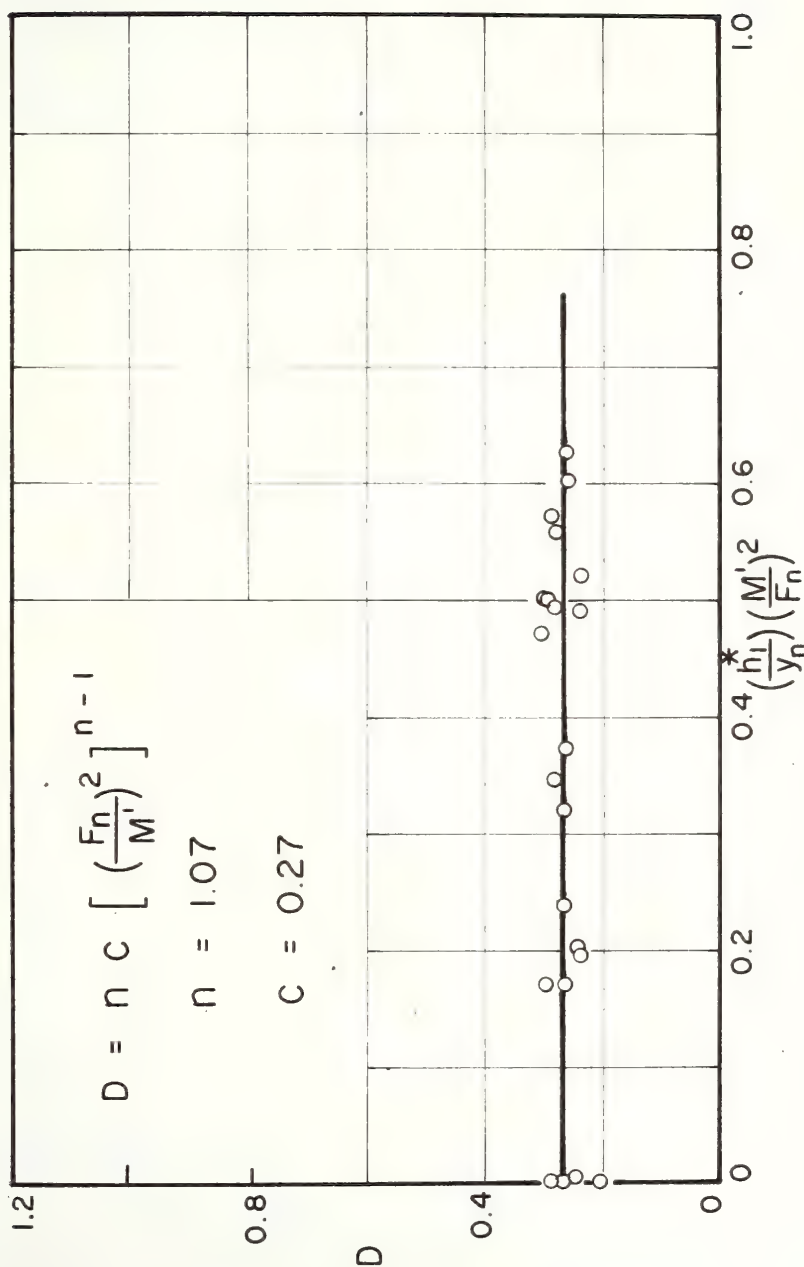


FIGURE 7-4-17 BACKWATER RATIO COEFFICIENT, GEOMETRY III, ROUGH BOUNDARY  $\Phi_1 = 30^\circ$



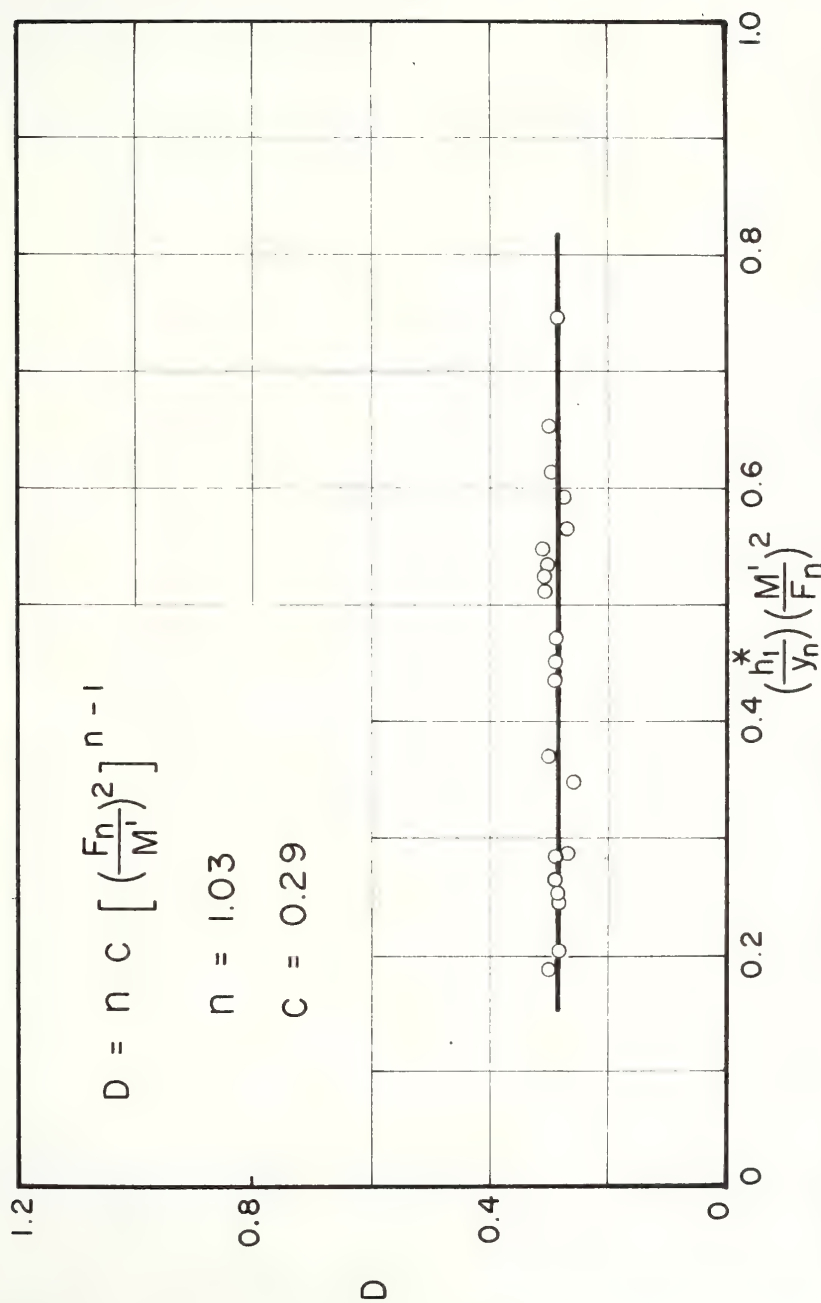


FIGURE 7-4-18 BACKWATER RATIO COEFFICIENT, GEOMETRY III ROUGH BOUNDARY  $\Phi_1 = 45^\circ$



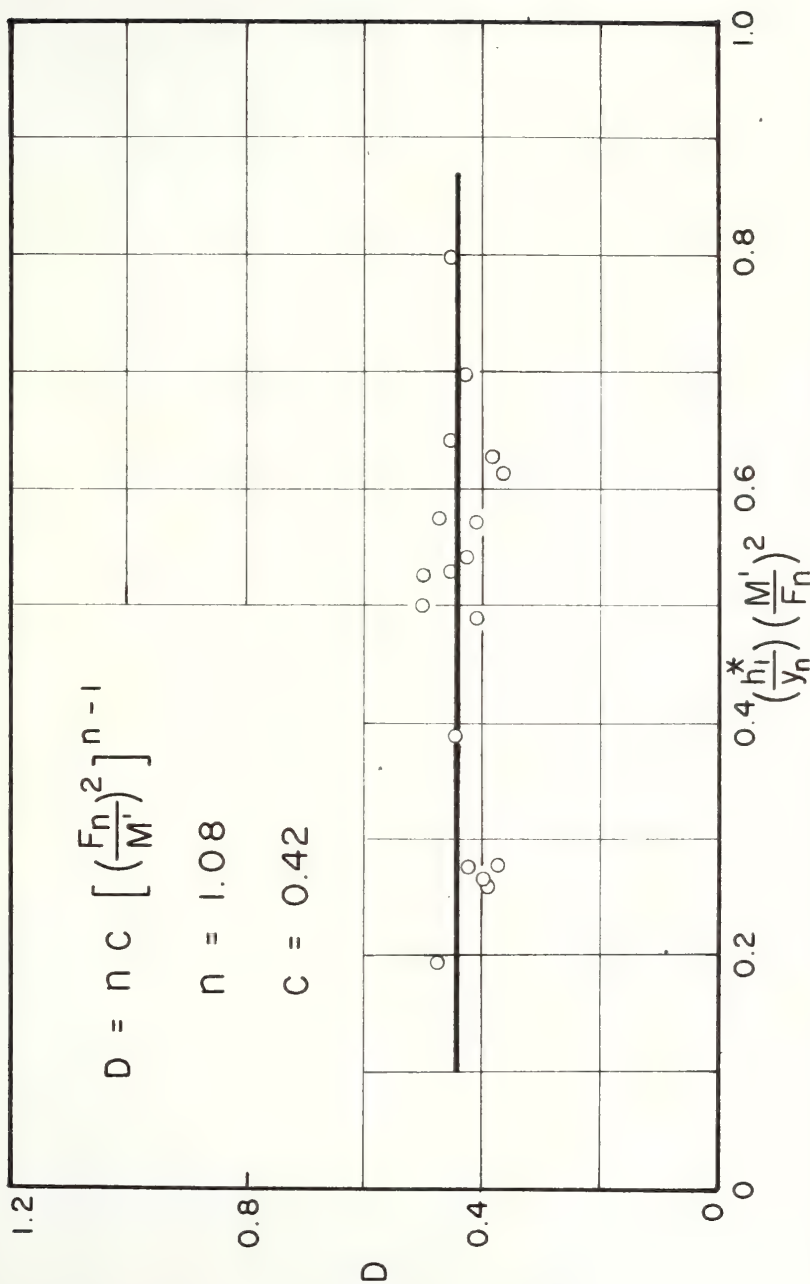


FIGURE 7-4-19 BACKWATER RATIO COEFFICIENT, GEOMETRY III, ROUGH BOUNDARY  $\Phi_1 = 60^\circ$



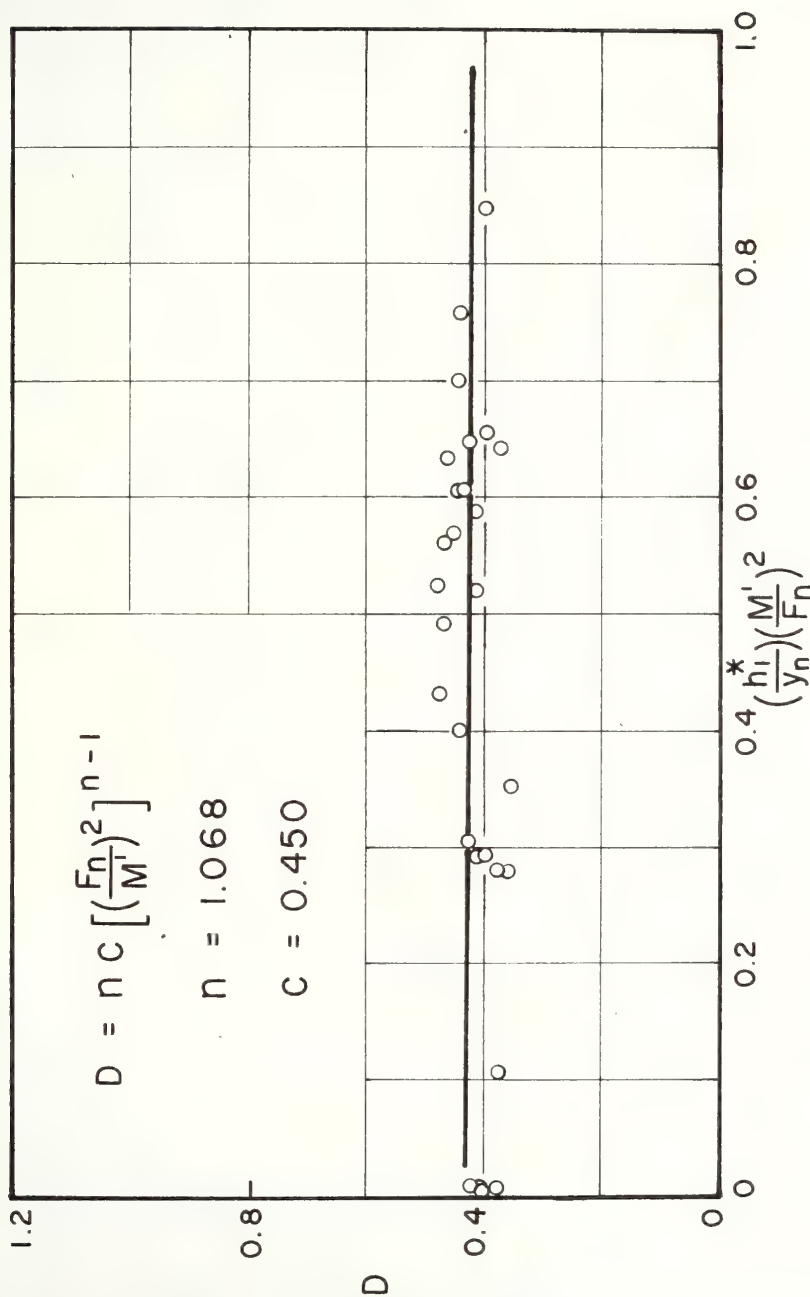


FIGURE 7-4-20 BACKWATER RATIO COEFFICIENT, GEO-METRY III, ROUGH BOUNDARY  $\Phi_1 = 90^\circ$





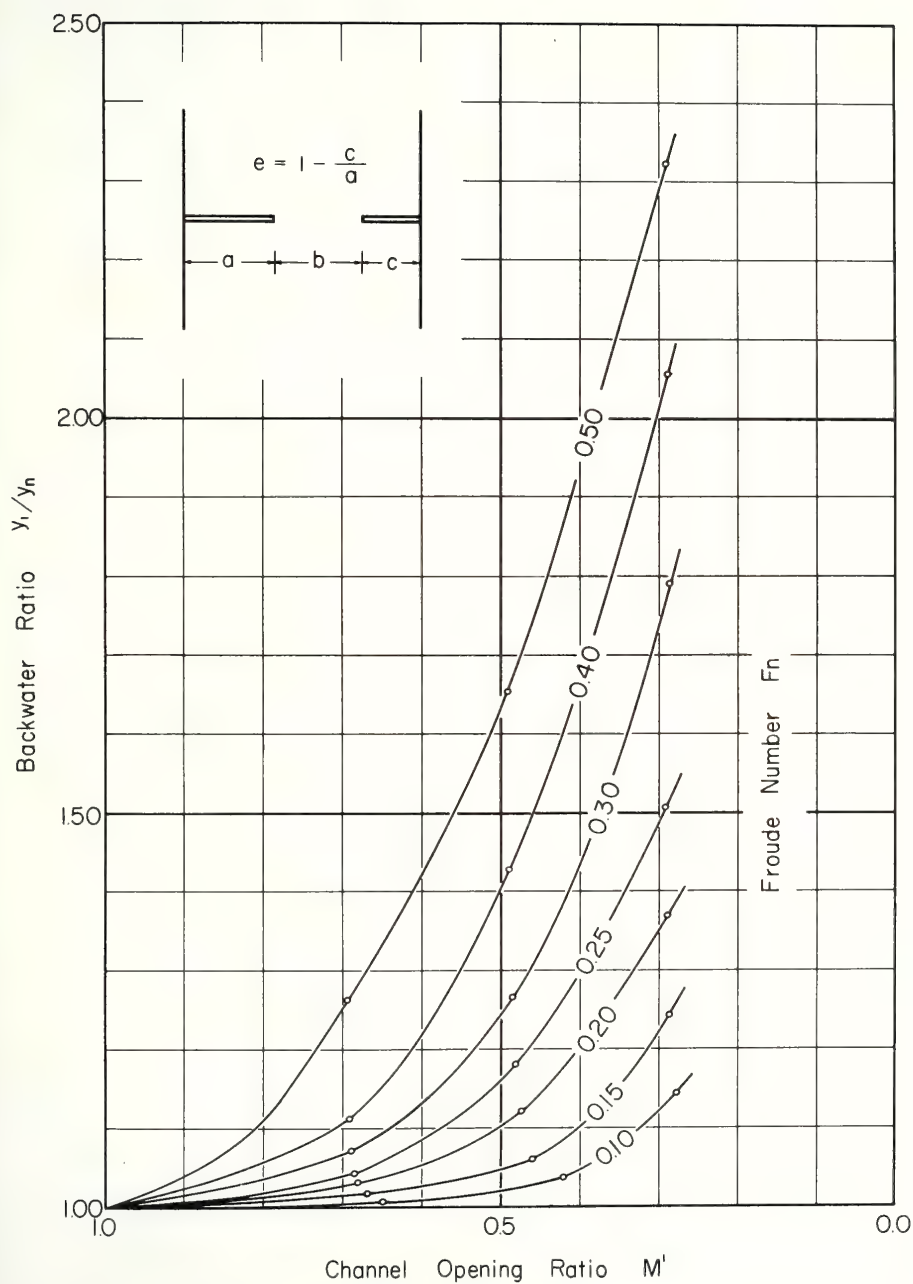


FIG. 7-5-1 BACKWATER RATIO FOR ECCENTRIC ARCH BRIDGES

$$e = 0$$



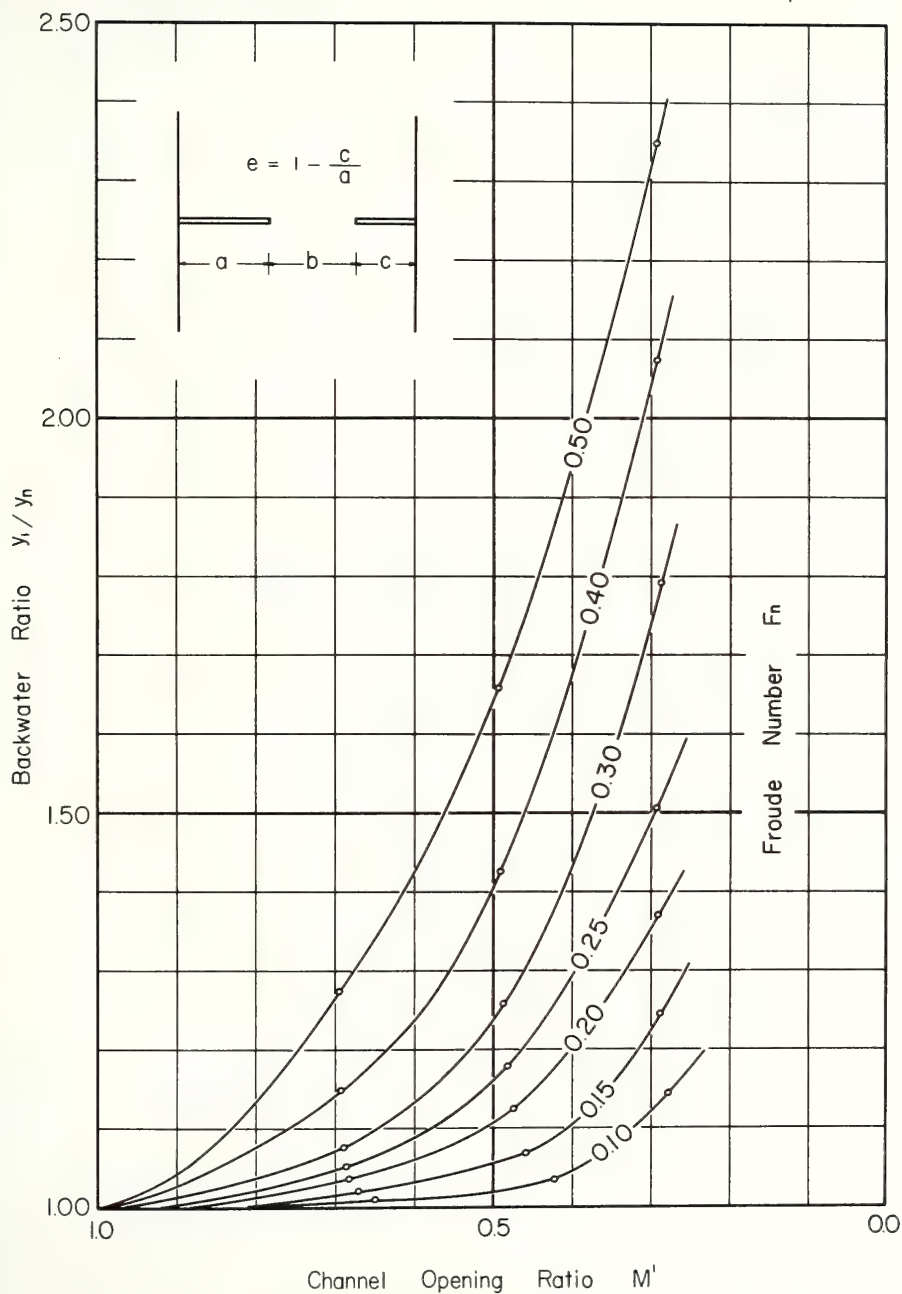


FIG. 7-5-2 - BACKWATER RATIO FOR ECCENTRIC ARCH BRIDGES

$$e = .80$$



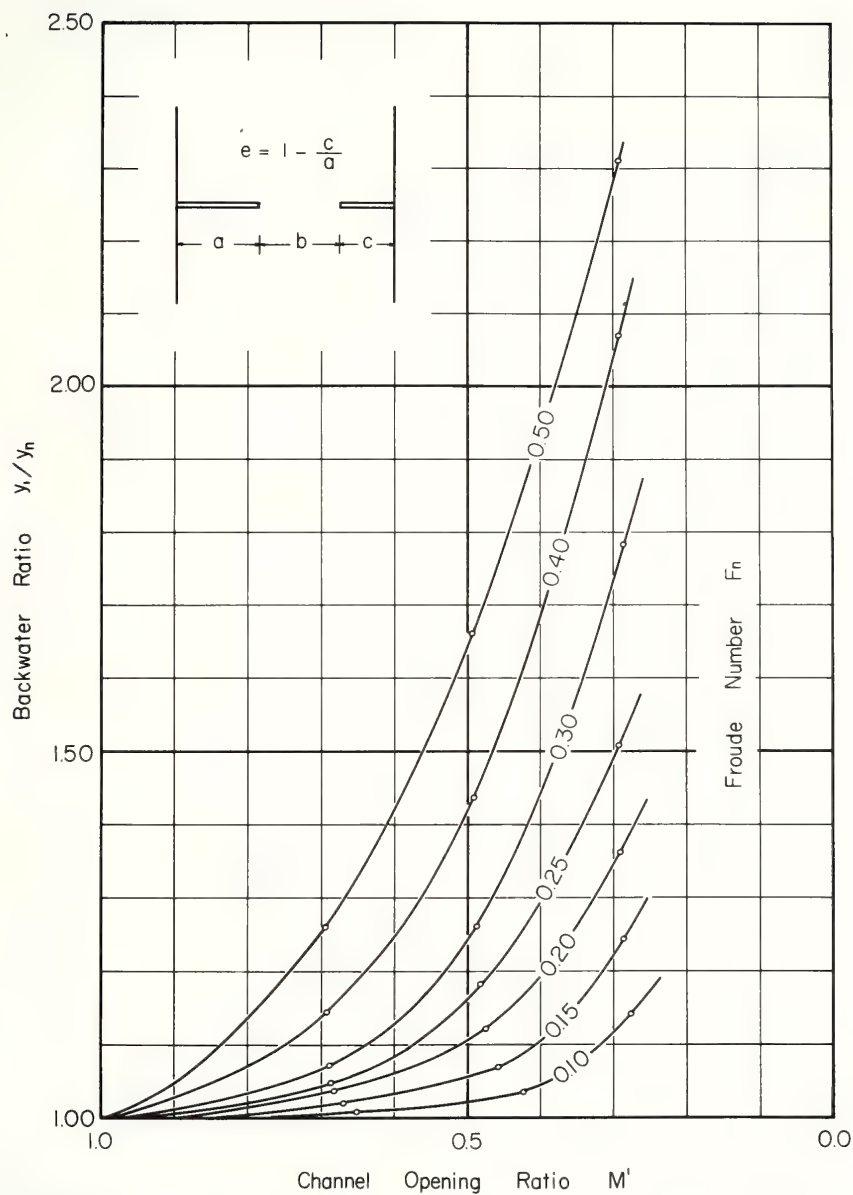


FIG. 7-5-3-BACKWATER RATIO FOR ECCENTRIC ARCH BRIDGES

$$e = .85$$



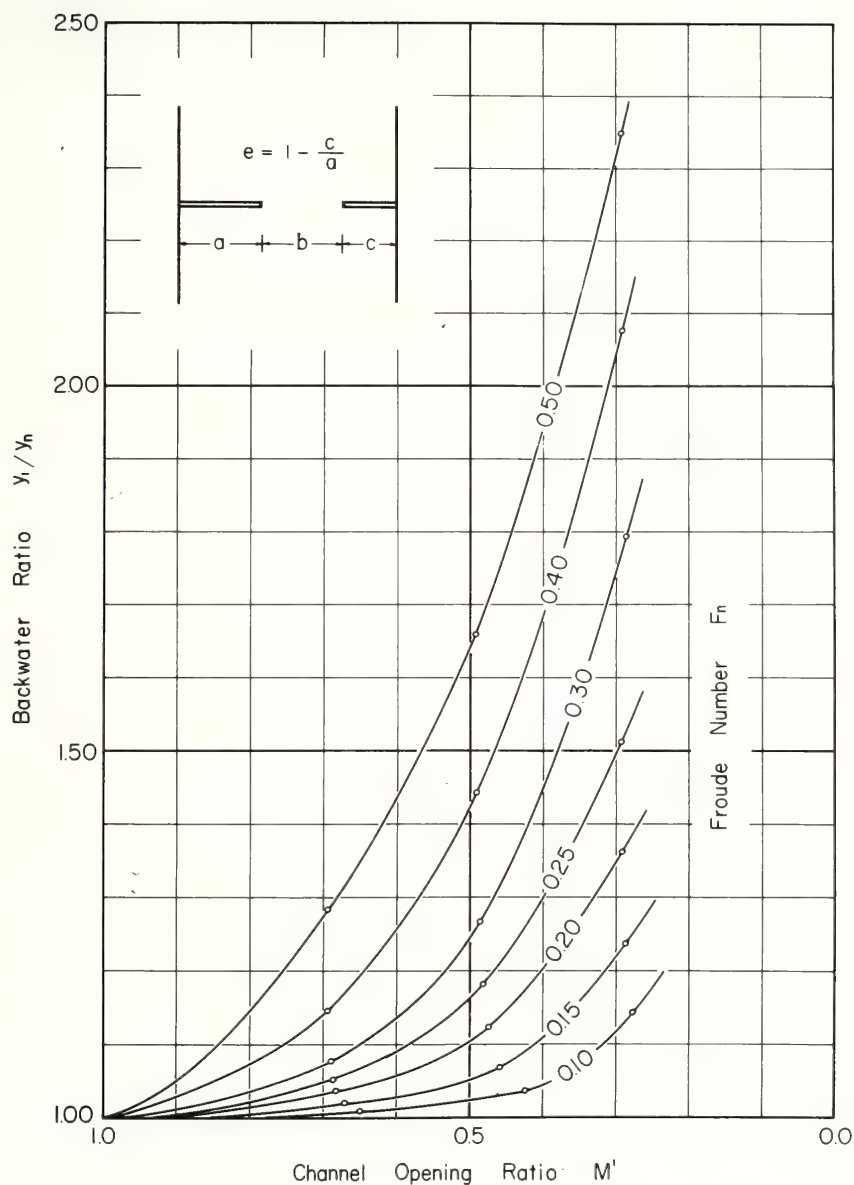


FIG. 7-5-4 BACKWATER RATIO FOR ECCENTRIC ARCH BRIDGES

$$e = .90$$





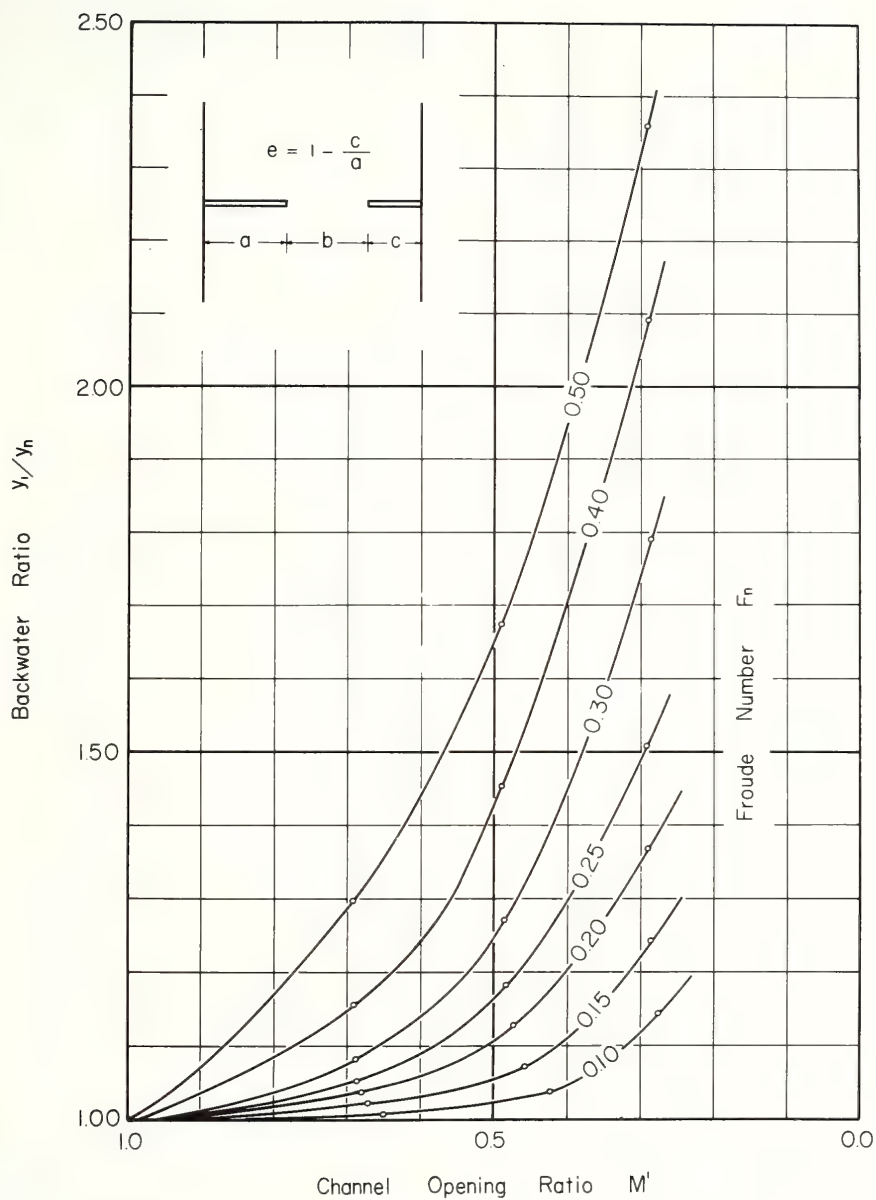


FIG. 7-5-5 - BACKWATER RATIO FOR ECCENTRIC ARCH BRIDGES

$$e = .95$$



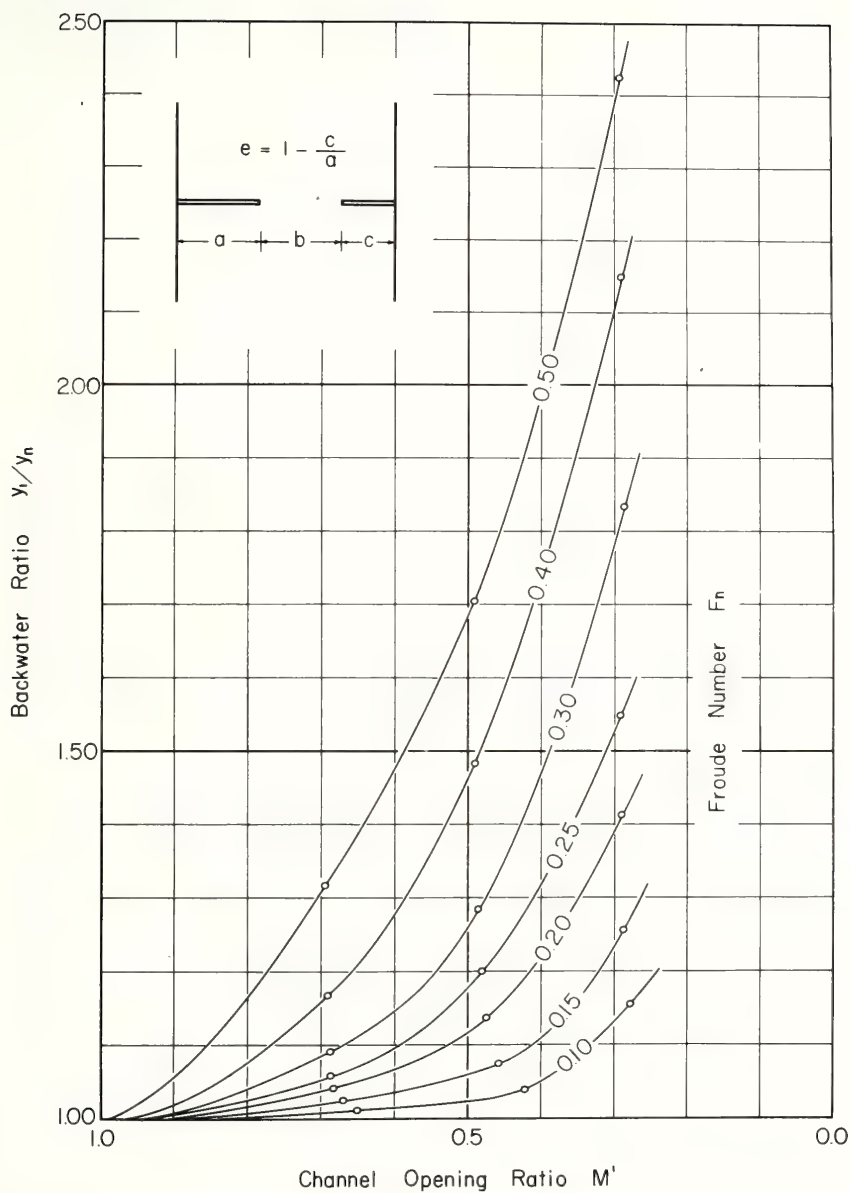


FIG. 7-5-6 - BACKWATER RATIO FOR ECCENTRIC ARCH BRIDGES

$$e = 100$$



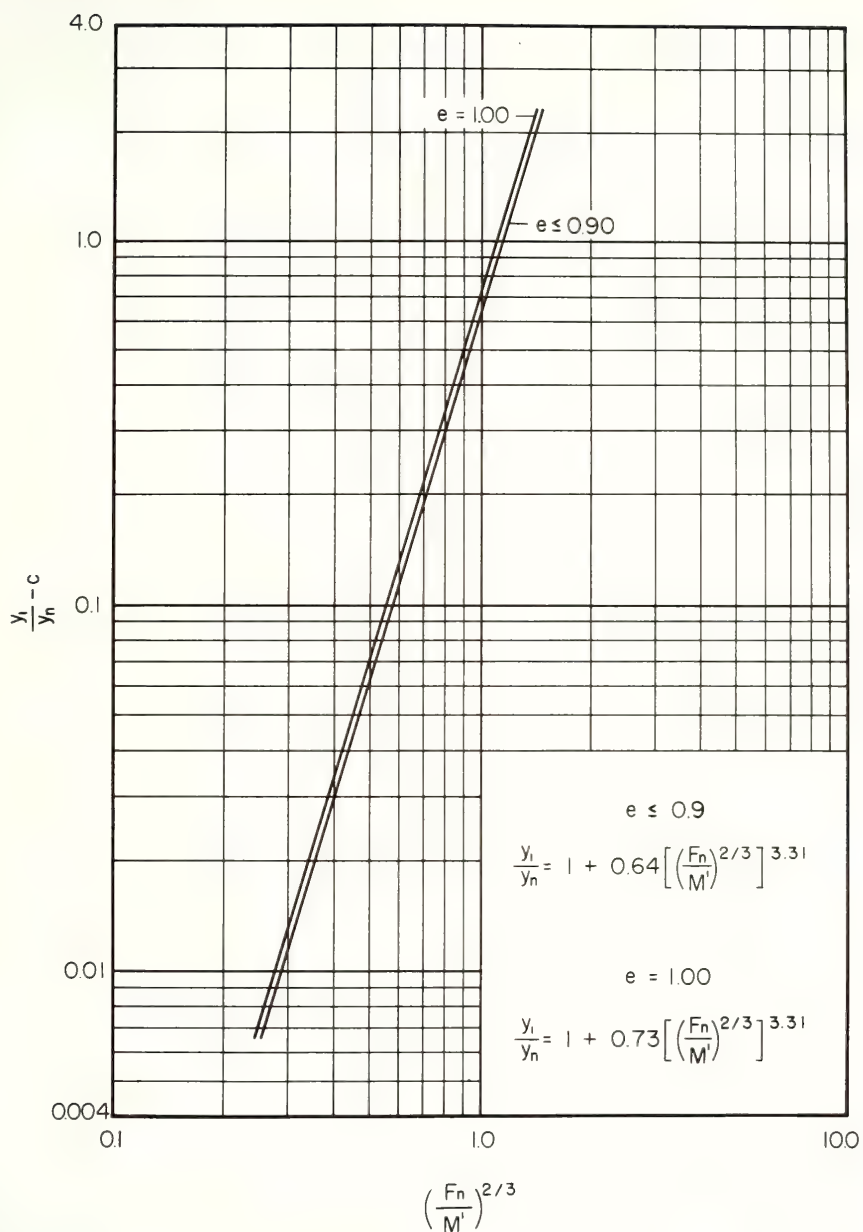


FIG. 7-5-7 - GENERALIZED BACKWATER RATIO  
FOR ECCENTRIC ARCH BRIDGE



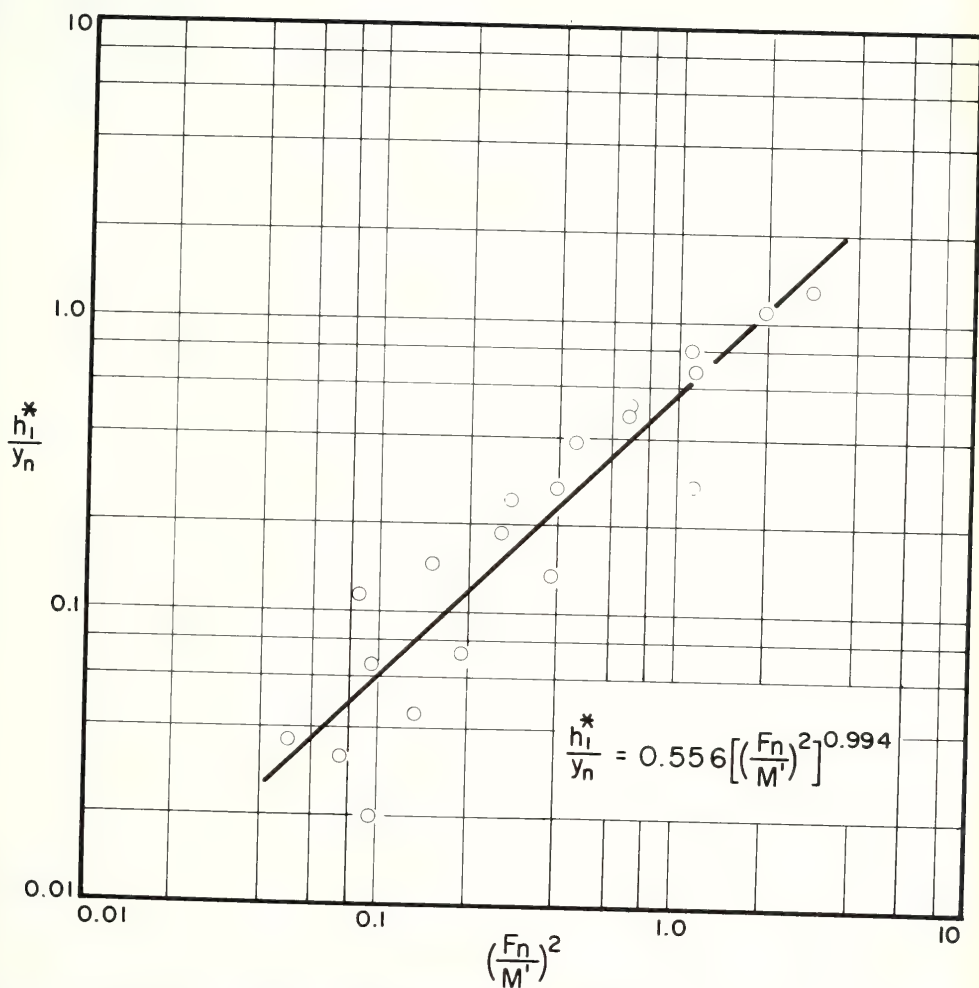


FIGURE 7-5-8 BACKWATER RATIO, GEOMETRY IV  
ROUGH BOUNDARY  $e = 0.0$





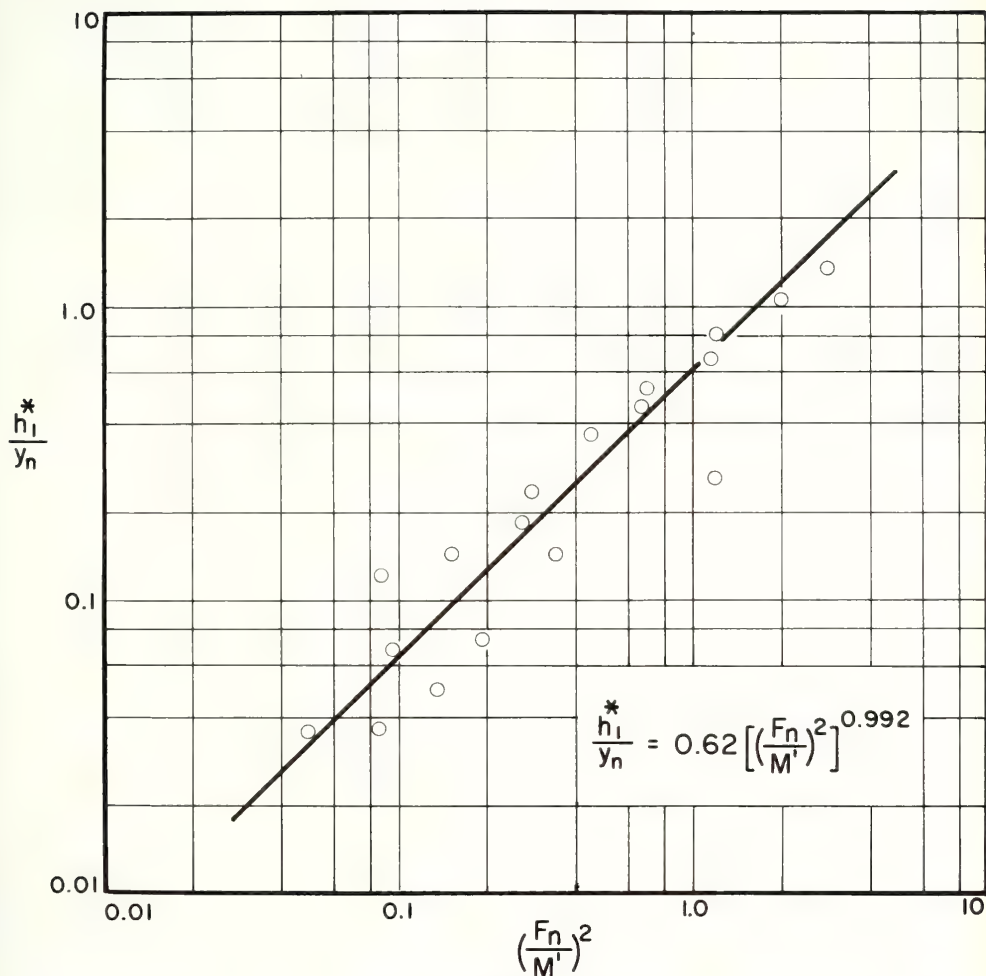


FIGURE 7-5 - 9 BACKWATER RATIO, GEOMETRY IV  
ROUGH BOUNDARY  $e = 0.8$



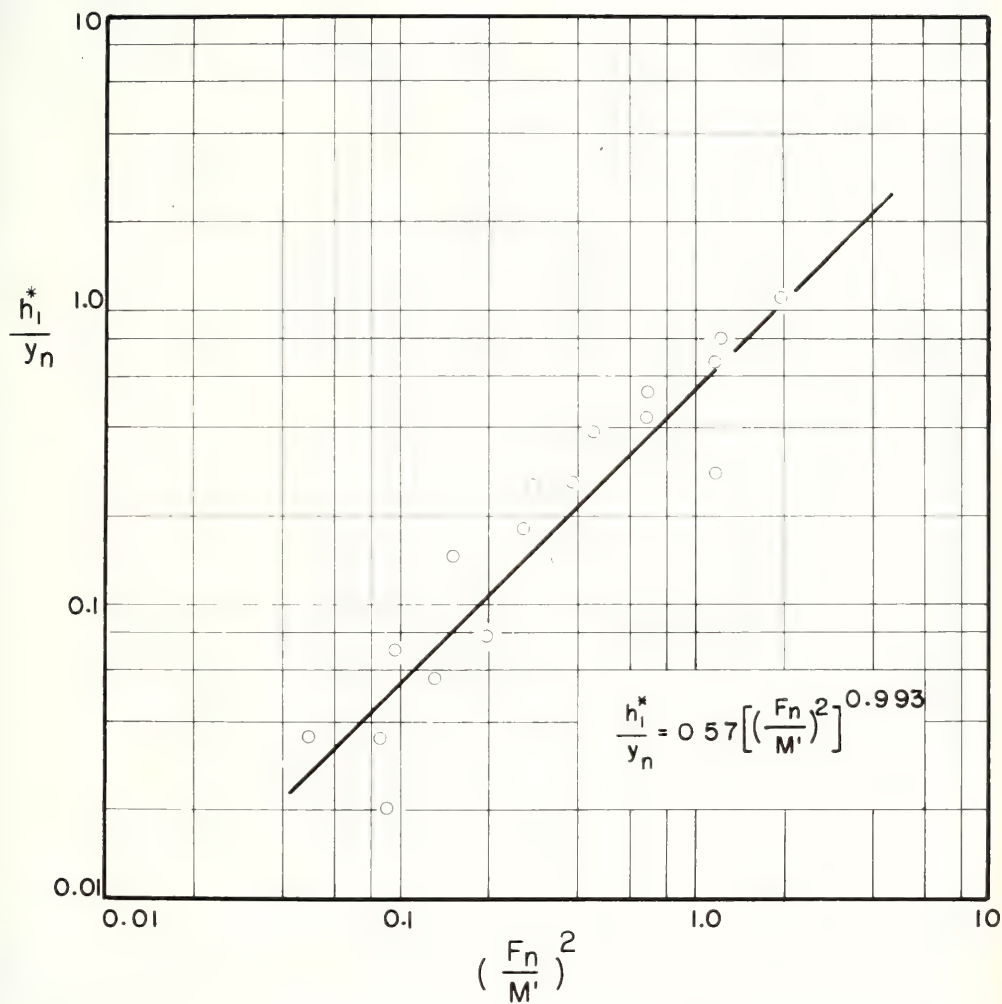


FIGURE 7-5-10 BACKWATER RATIO GEOMETRY IV  
ROUGH BOUNDARY  $e = 0.85$



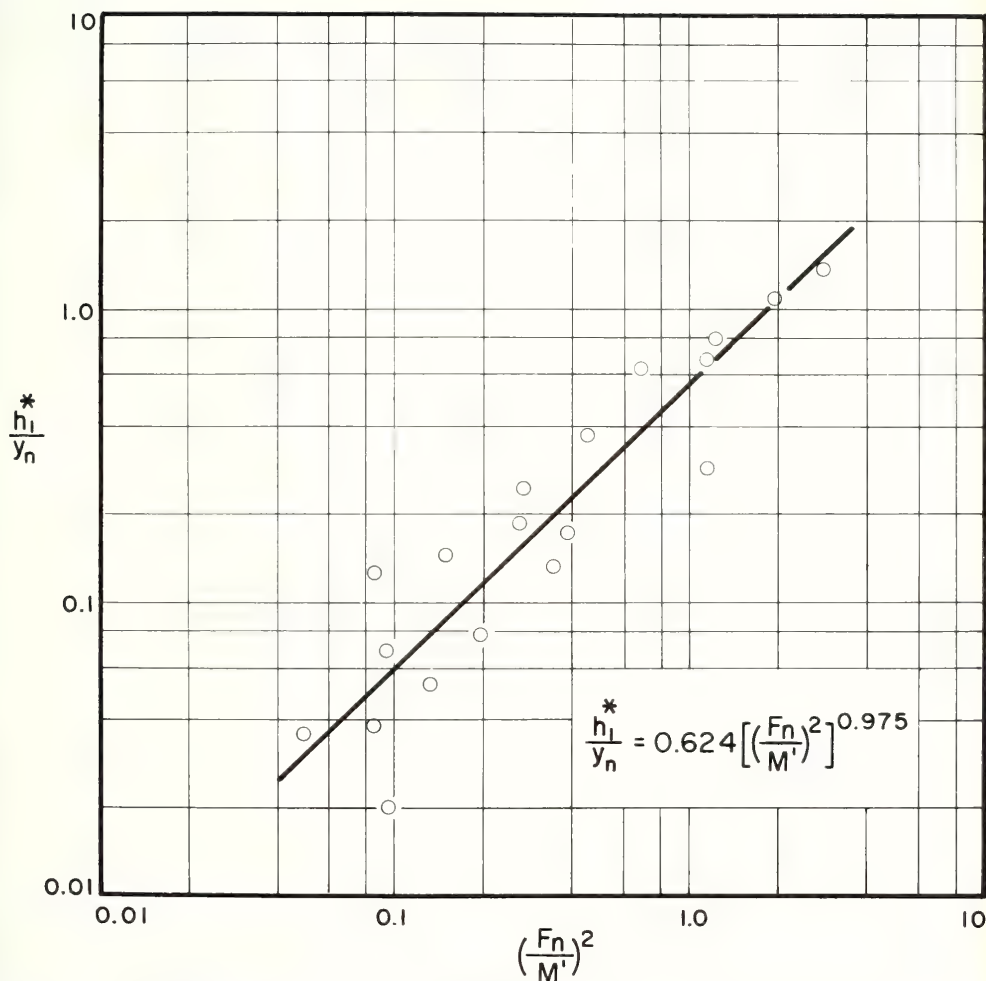


FIGURE 7-5-II BACKWATER RATIO, GEOMETRY IV  
ROUGH BOUNDARY  $e = 0.9$



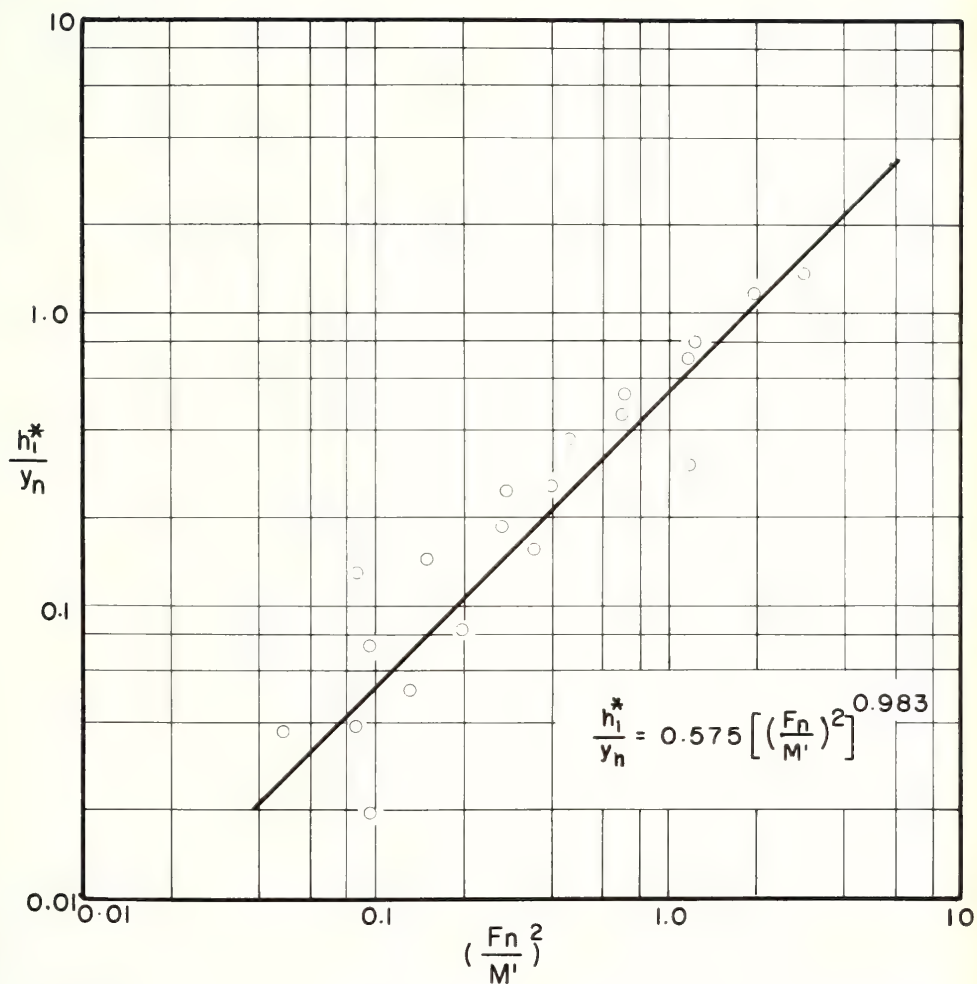


FIGURE 7-5-12 BACKWATER RATIO GEOMETRY IV

ROUGH BOUNDARY  $e = 0.95$





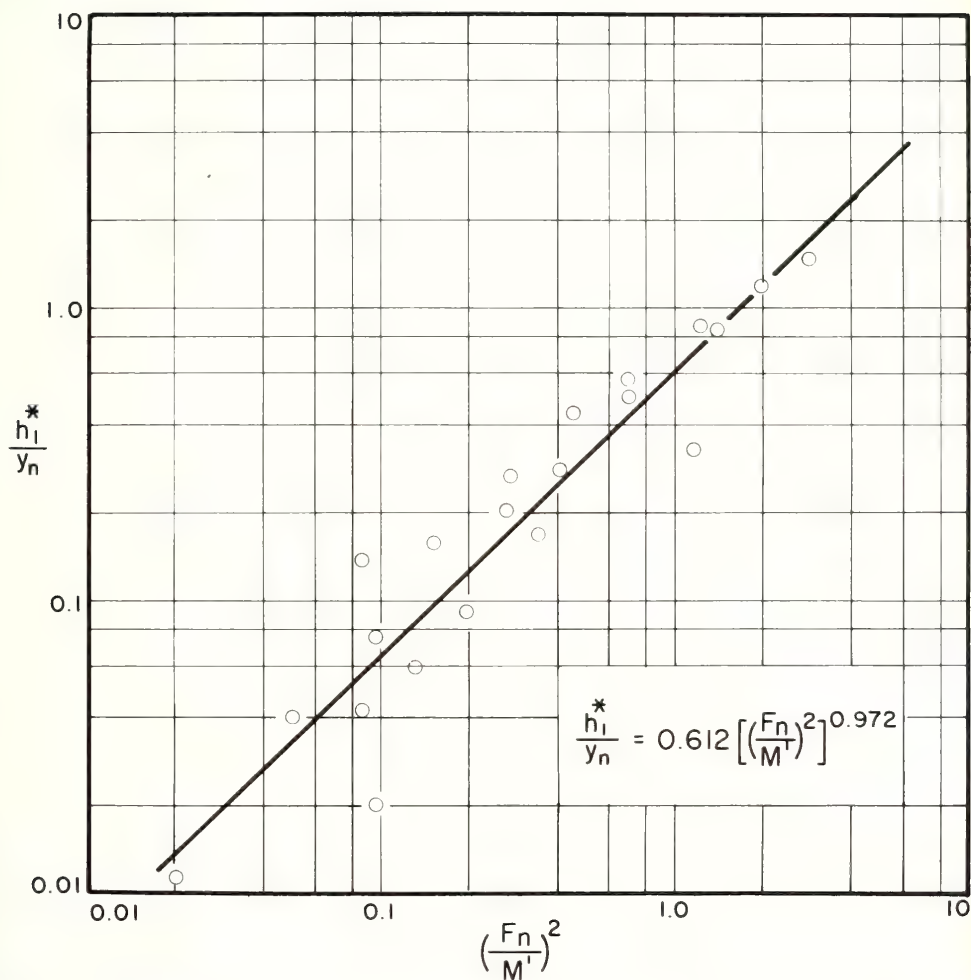


FIGURE 7-5-13 BACKWATER RATIO, GEOMETRY IV  
ROUGH BOUNDARY  $e = 1.0$



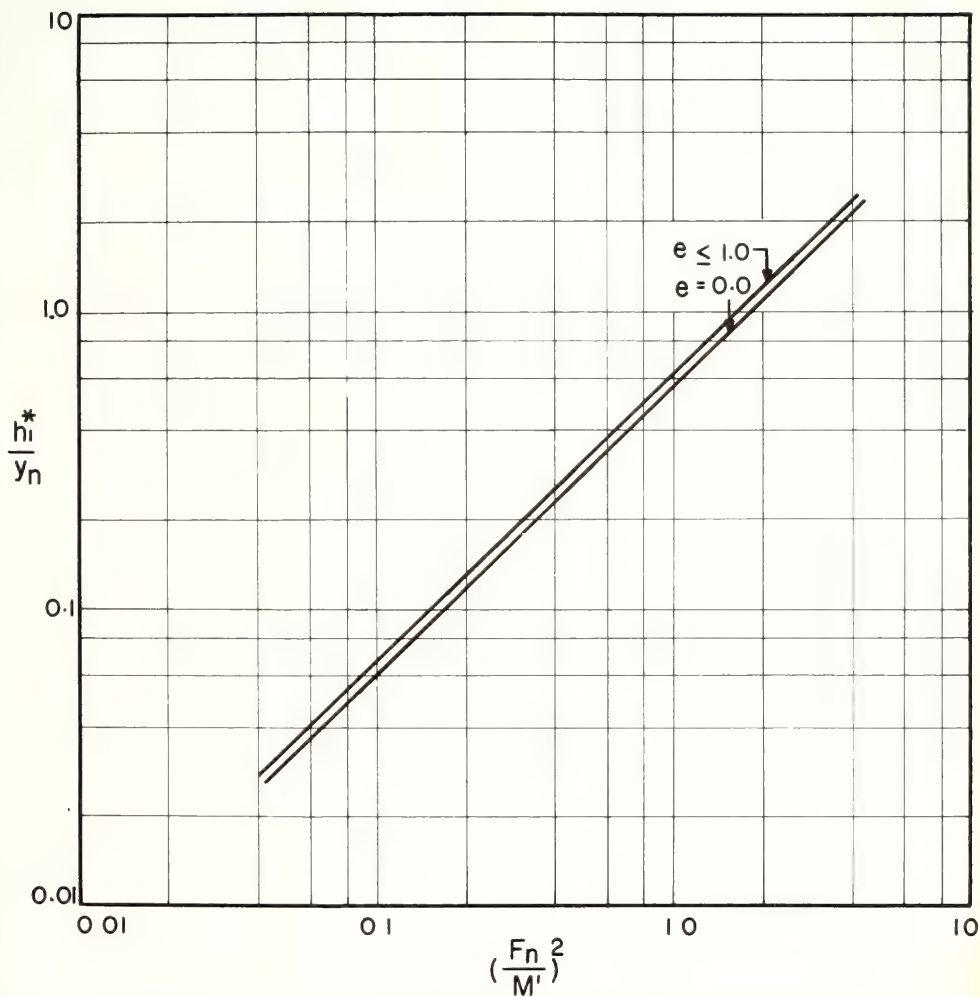


FIGURE 7-5-14 SUMMARY OF BACKWATER RATIO  
GEOMETRY IV ROUGH BOUNDARY



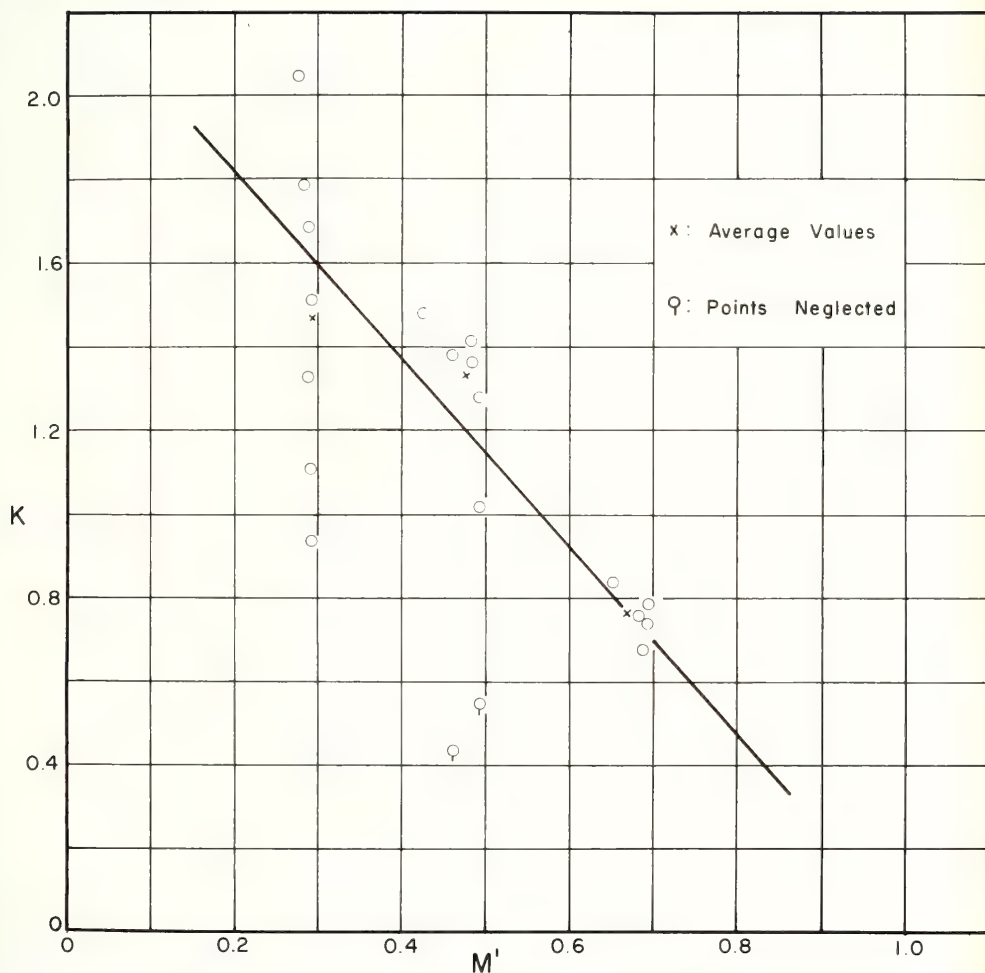


FIGURE 7-5-15 HEAD LOSS COEFFICIENT, GEOMETRY IV  
ROUGH BOUNDARY  $e = 0.00$



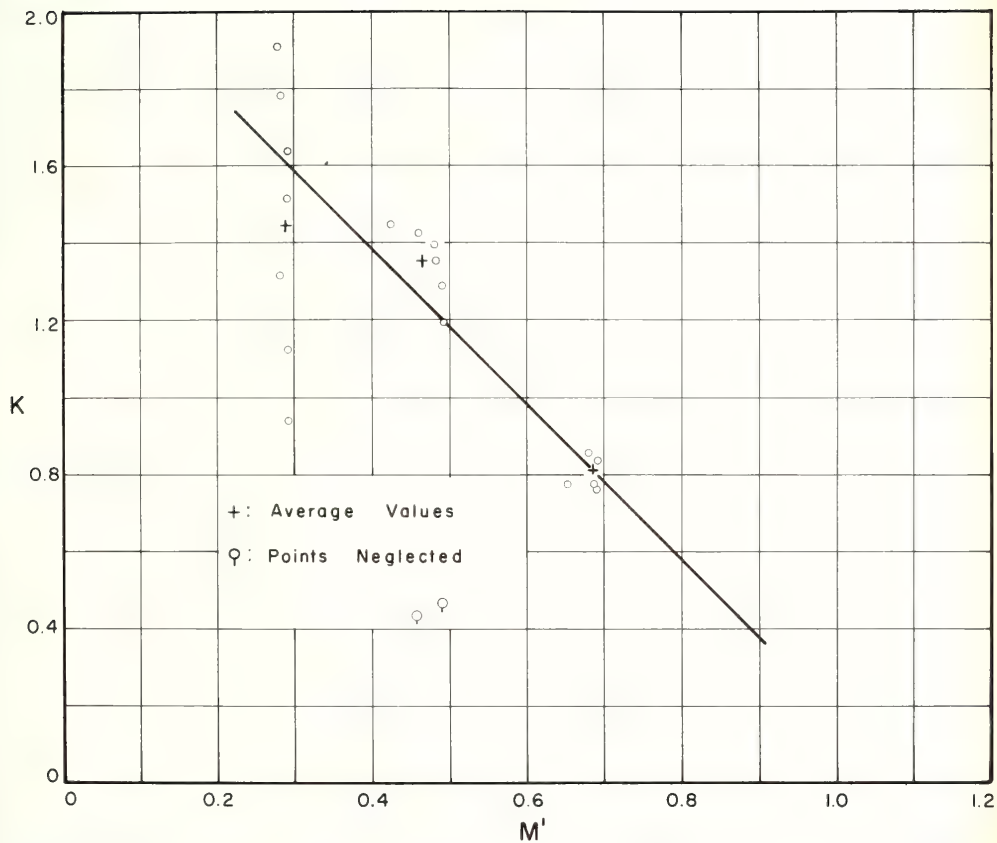
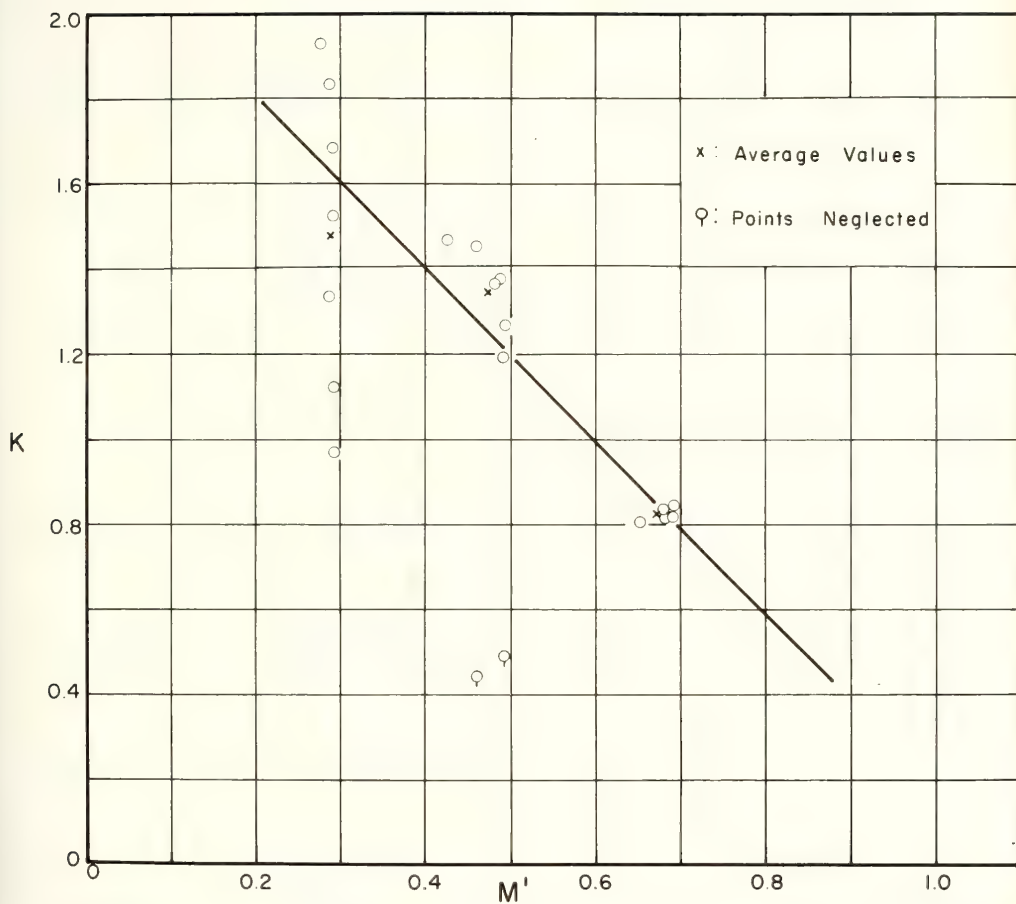


FIGURE 7-5-16 HEAD LOSS COEFFICIENT, GEOMETRY IV  
ROUGH BOUNDARY  $e = 0.8$









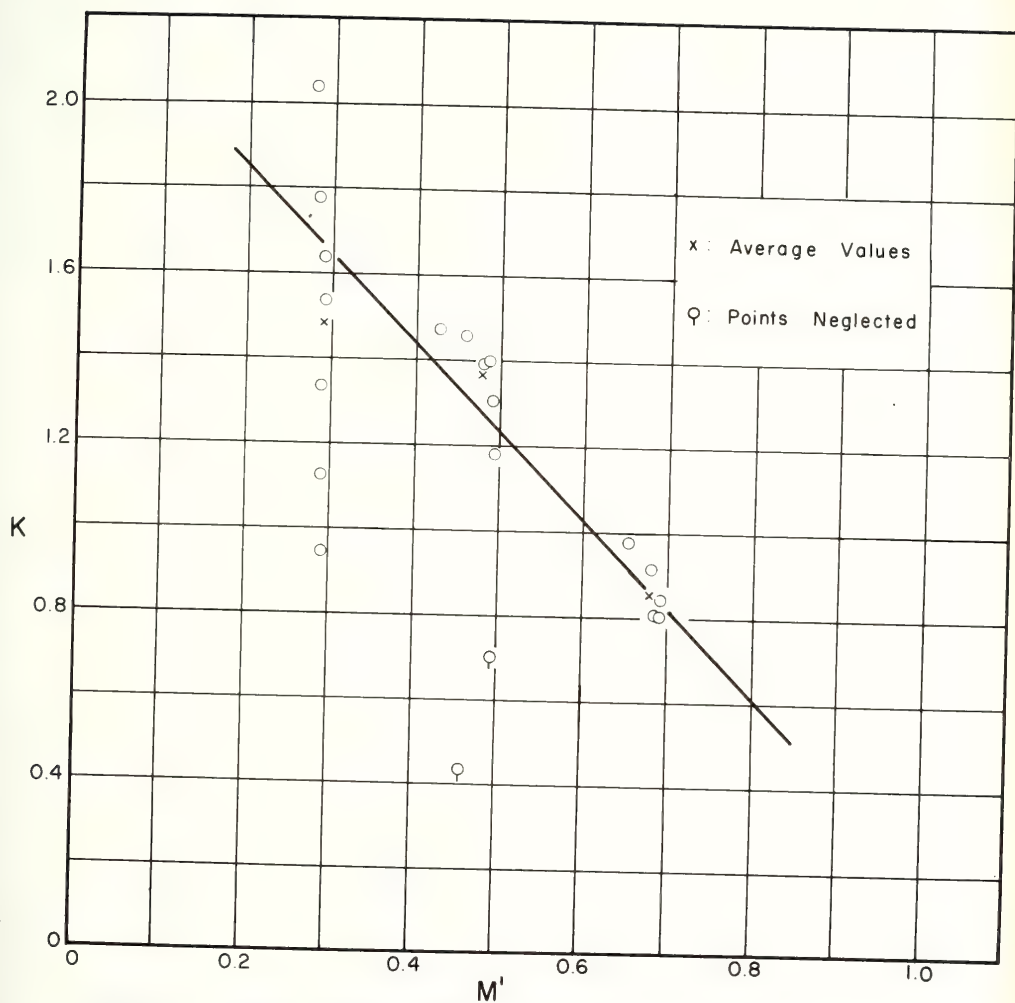


FIGURE 7-5-18 HEAD LOSS COEFFICIENT, GEOMETRY IV  
ROUGH BOUNDARY  $e = 0.9$



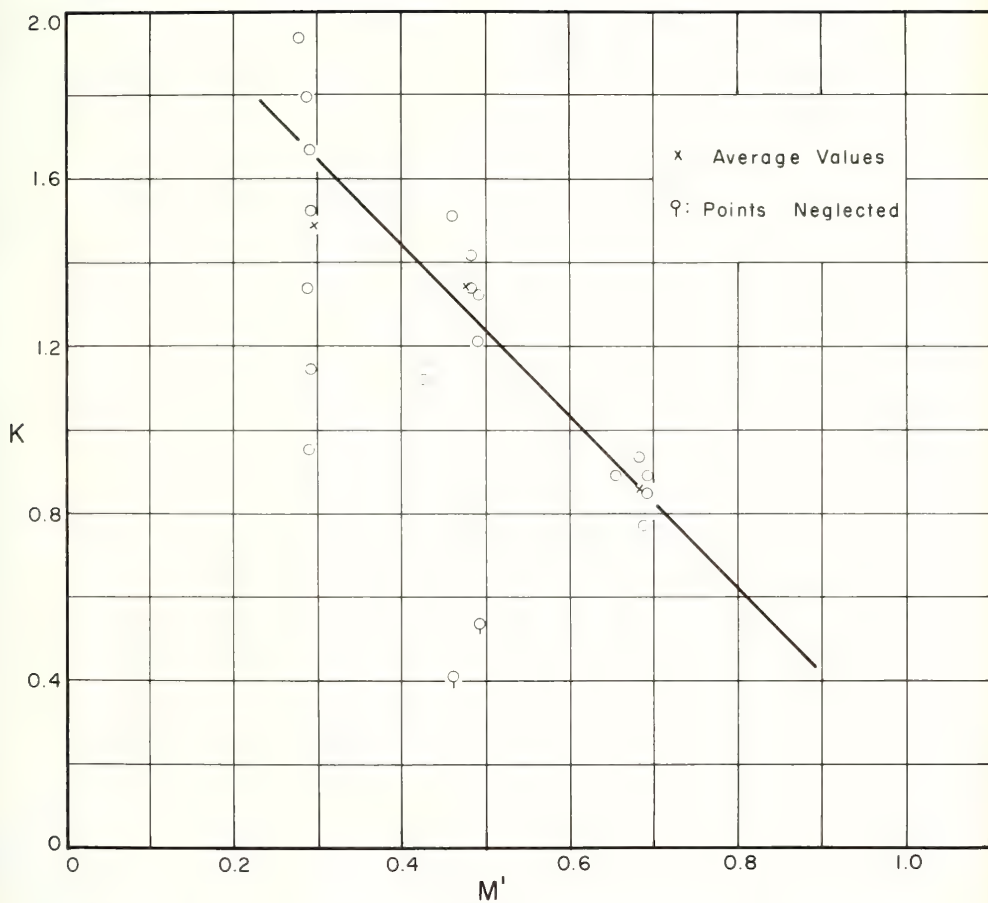


FIGURE 7-5-19 HEAD LOSS COEFFICIENT, GEOMETRY IV  
ROUGH BOUNDARY  $e = 0.95$



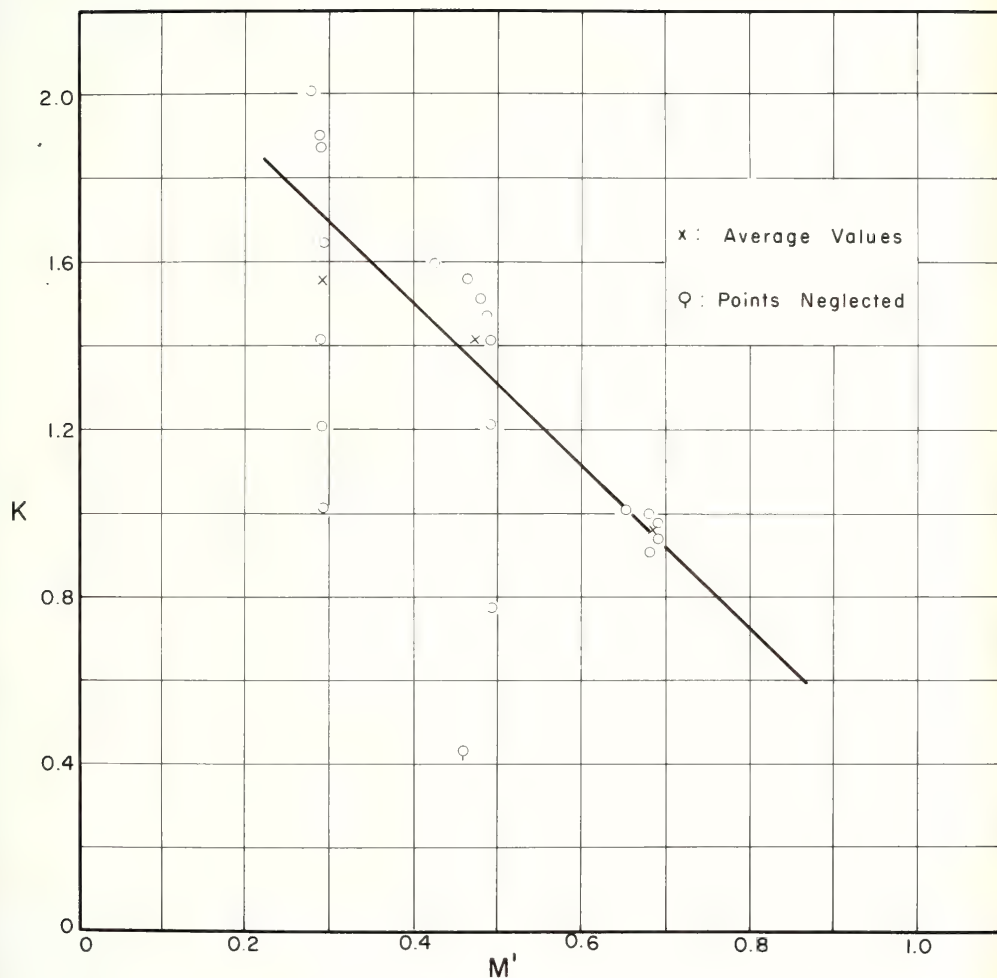


FIGURE 7-5-20 HEAD LOSS COEFFICIENT, GEOMETRY IV  
ROUGH BOUNDARY  $e = 1.0$





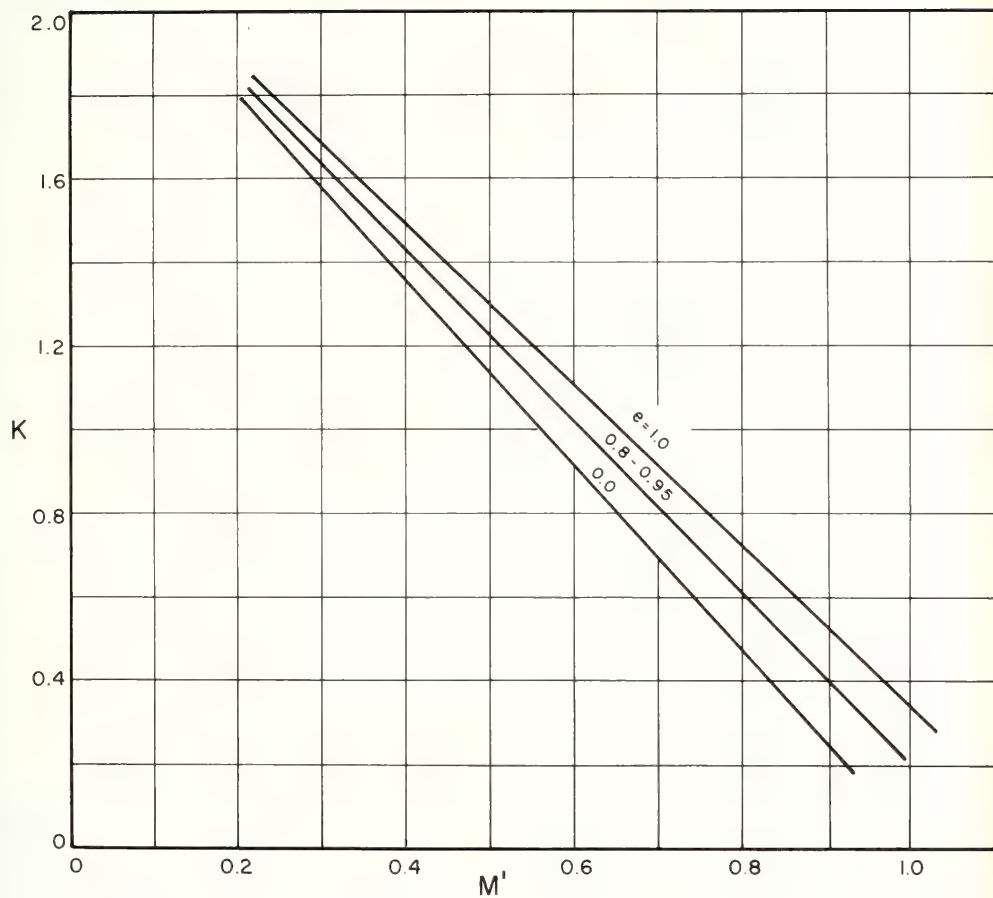


FIGURE 7-5-21 SUMMARY OF HEAD LOSS COEFFICIENTS  
GEOMETRY IV ROUGH BOUNDARY



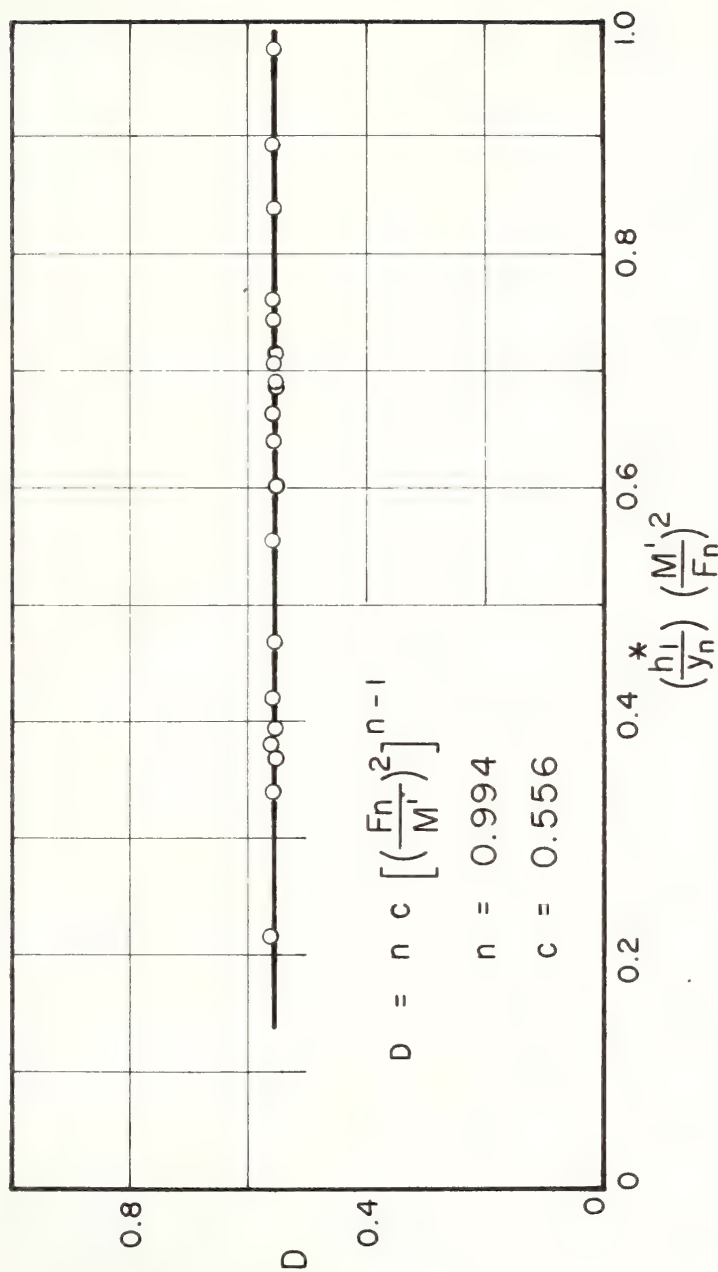


FIGURE 7-5-22 BACKWATER RATIO COEFFICIENT, GEOMETRY IV ROUGH BOUNDARY  $e = 0.0$



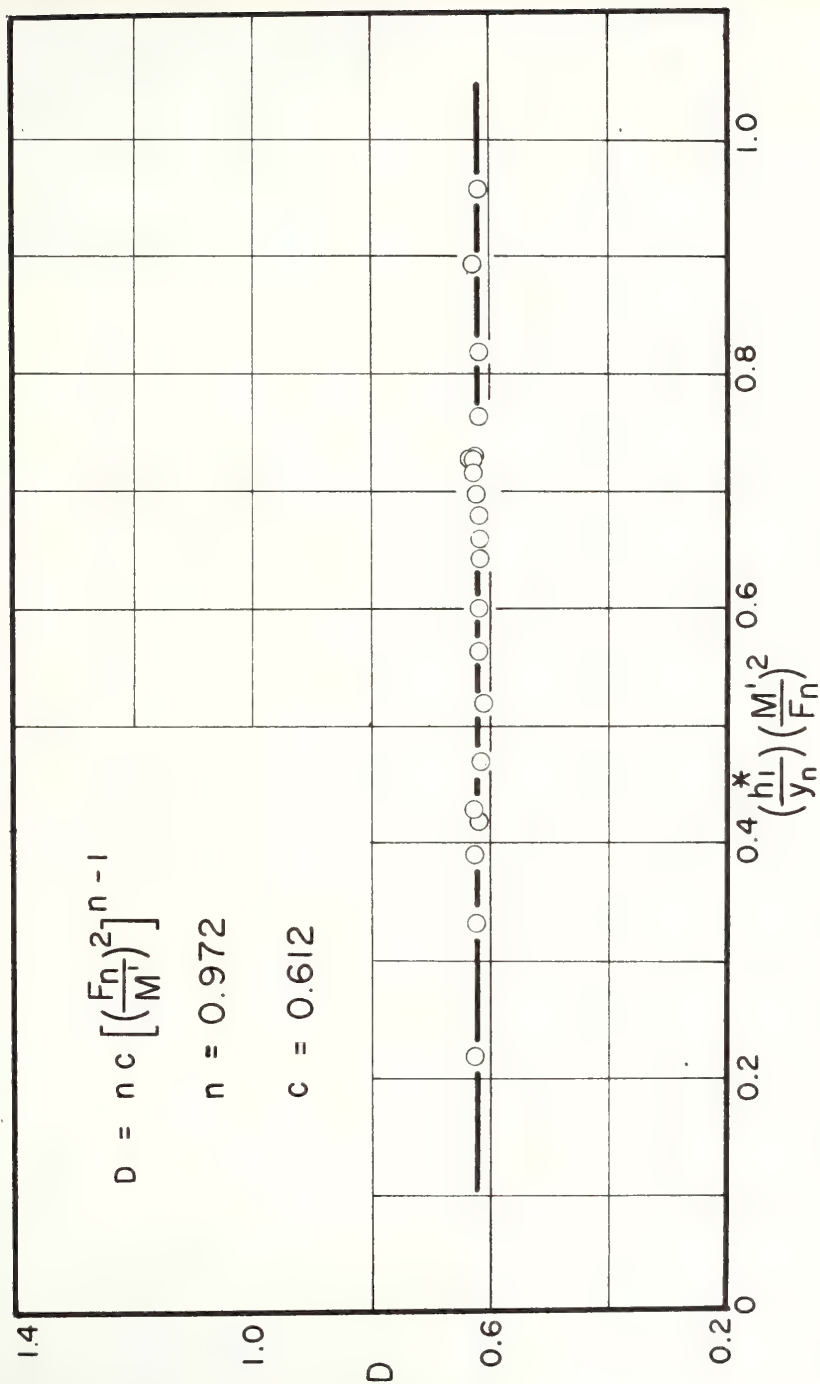


FIGURE 7-5-23 BACKWATER RATIO COEFFICIENT, GEOMETRY

IV ROUGH BOUNDARY  $e = 0.8$



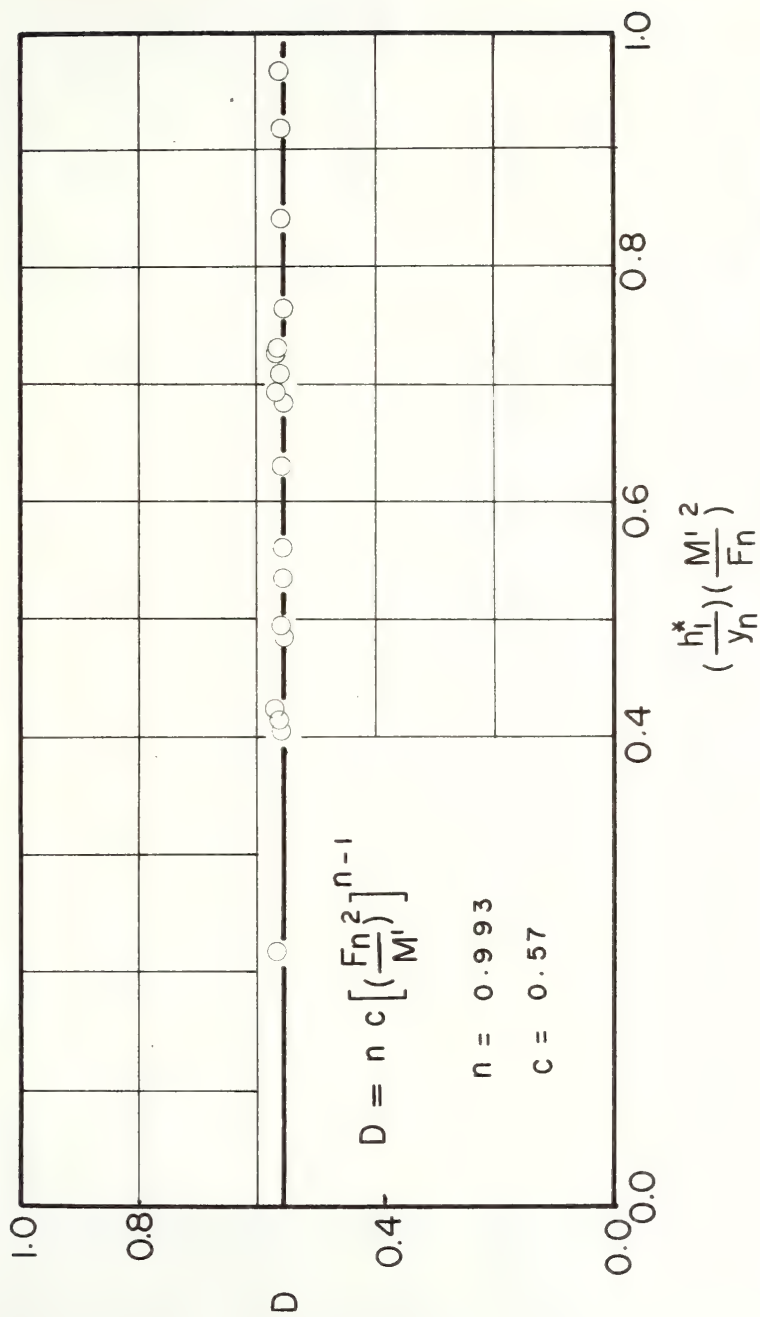


FIGURE 7-5-24 BACKWATER RATIO COEFFICIENT

GEOMETRY IV      ROUGH BOUNDARY       $e = 0.85$





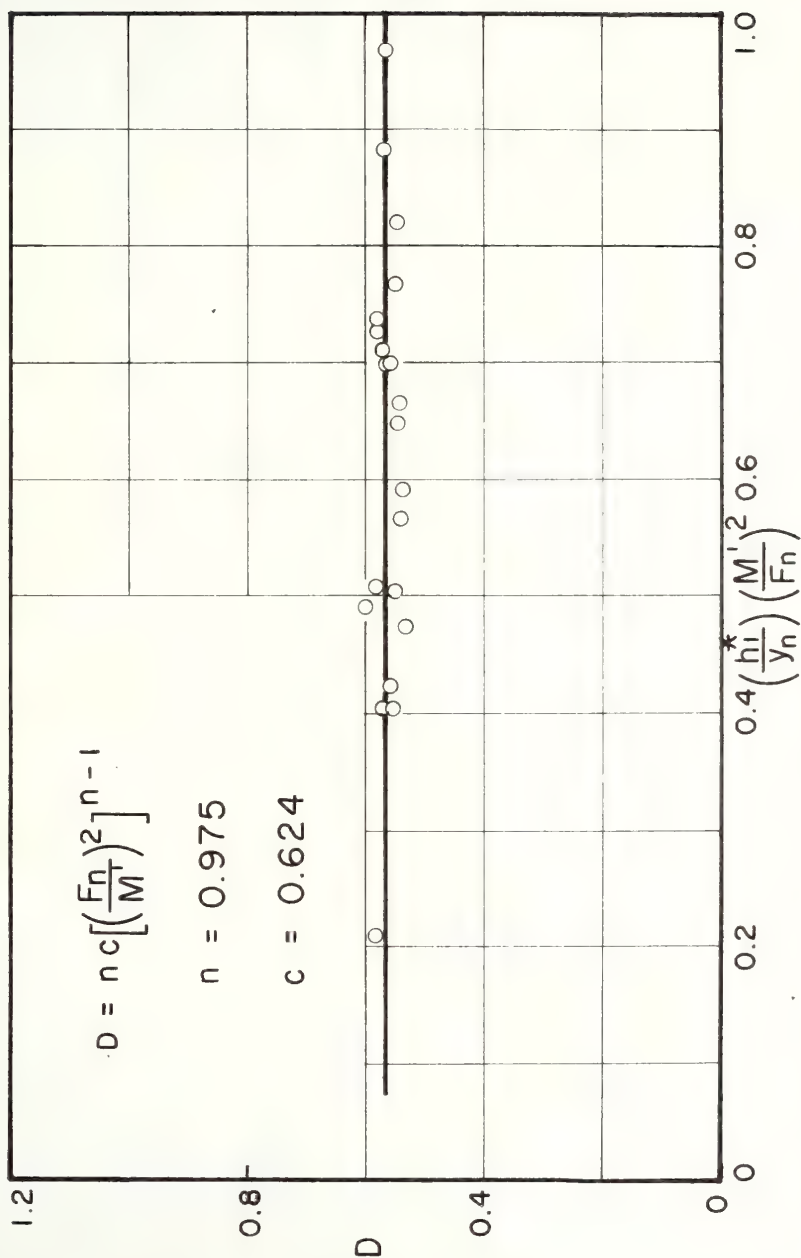


FIGURE 7-5-25 BACKWATER RATIO COEFFICIENT, GEOMETRY IV ROUGH BOUNDARY  $e = 0.9$



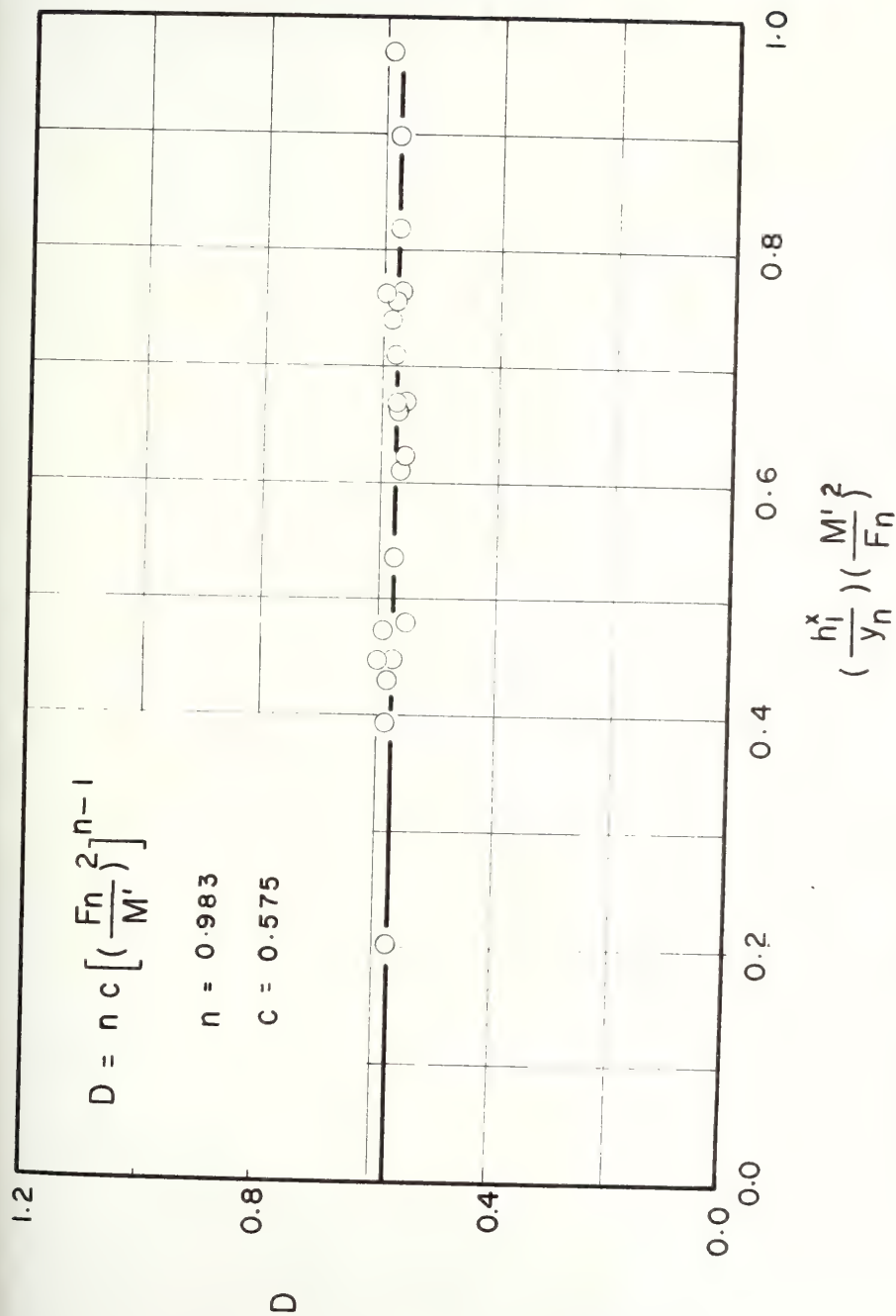


FIGURE 7-5-26 BACKWATER RATIO COEFFICIENT

GEOMETRY IV ROUGH BOUNDARY  $e = 0.95$



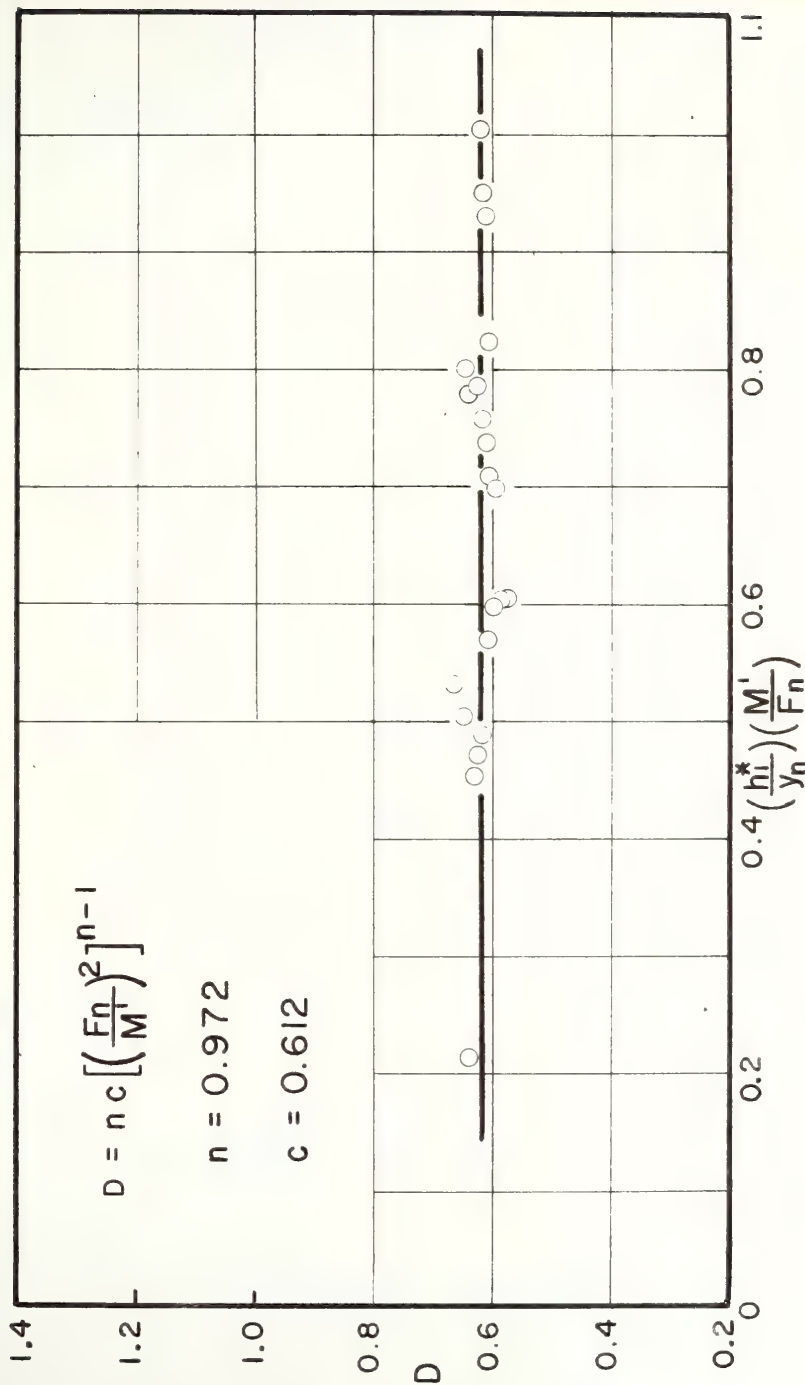


FIGURE 7-5-27 BACKWATER RATIO COEFFICIENT GEOMETRY

IV ROUGH BOUNDARY  $e = 1.0$



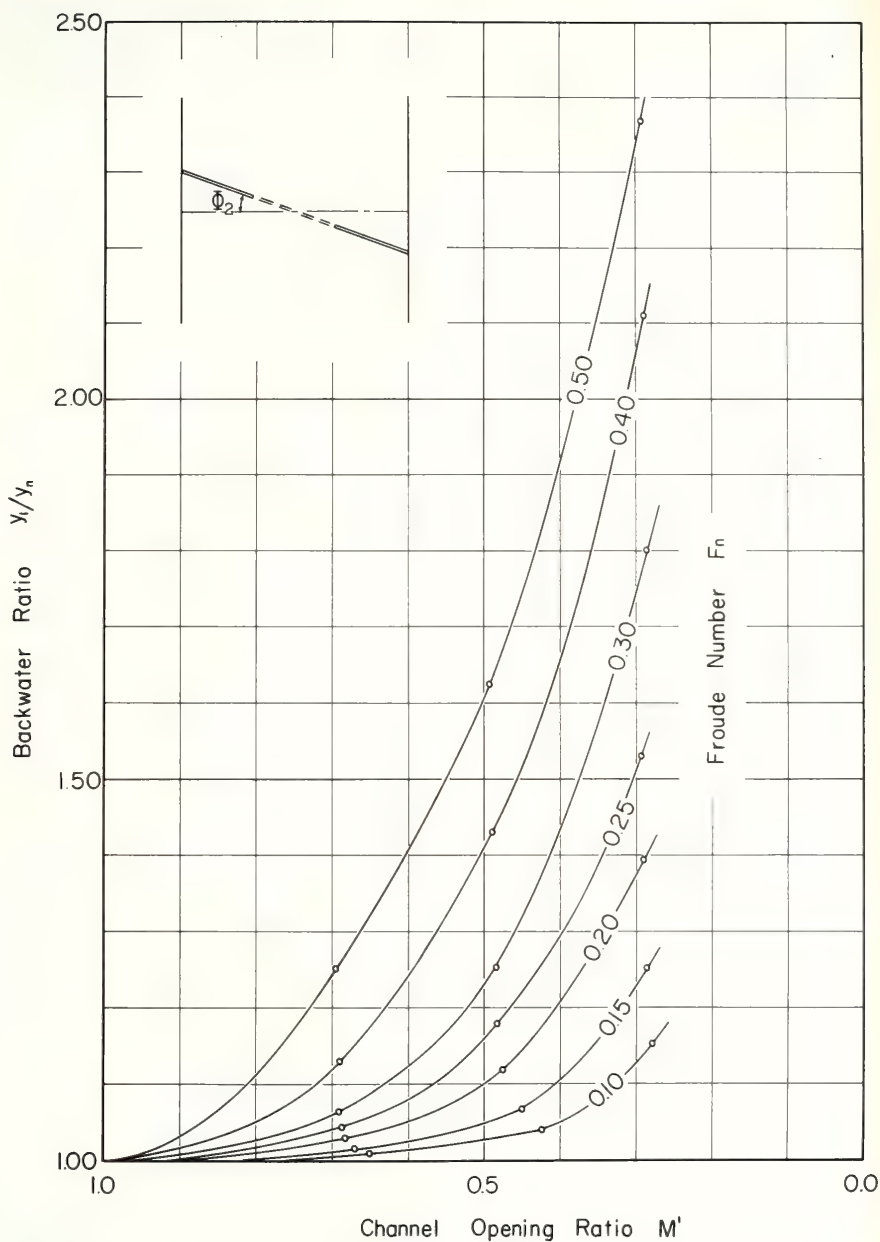


FIG. 7-6-1-BACKWATER RATIO FOR SKEW ARCH BRIDGES  
 $\Phi_2 = 0^\circ$





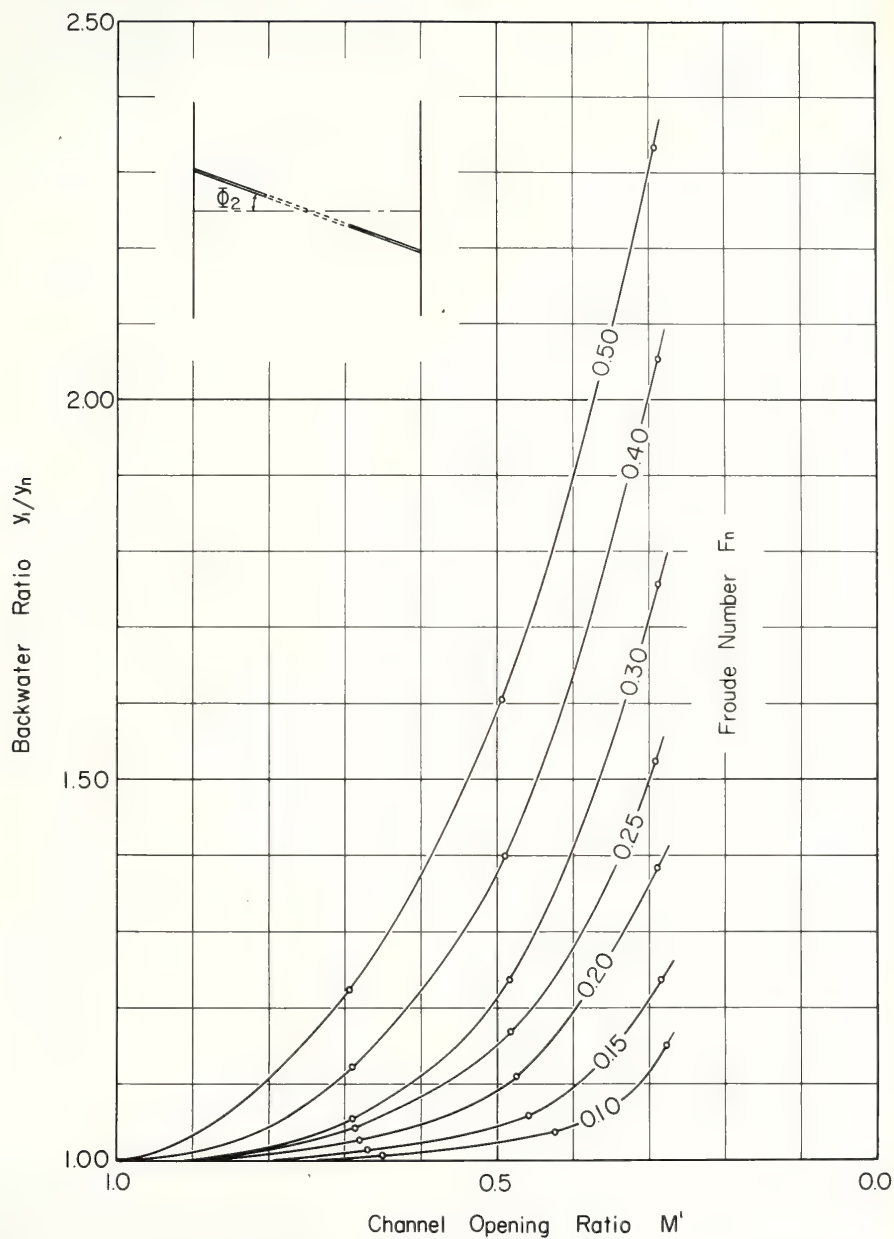


FIG. 7-6 -2 -BACKWATER RATIO FOR SKEW ARCH BRIDGES

$$\Phi_2 = 15^\circ$$



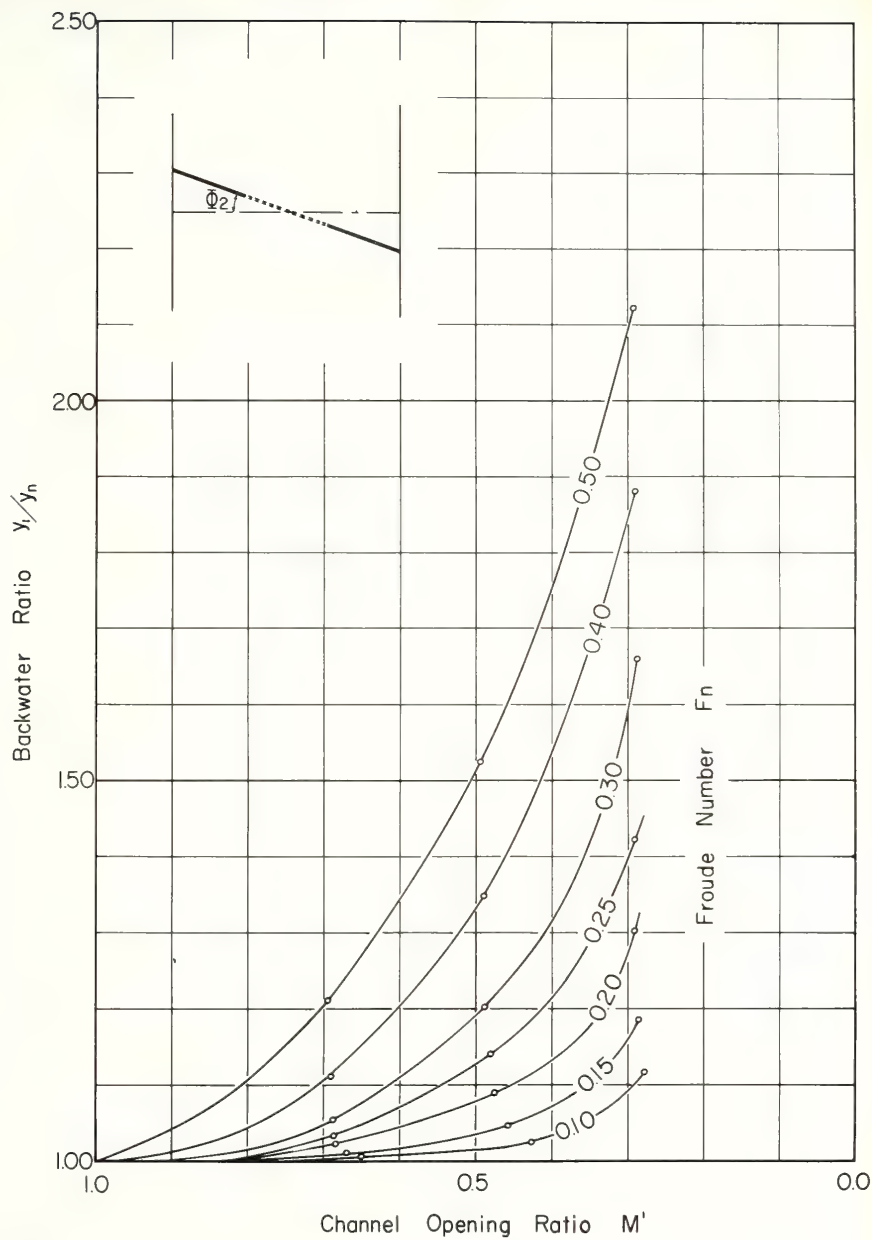


FIG. 7-6-3 -BACKWATER RATIO FOR SKEW ARCH BRIDGES

$$\Phi_2 = 30^\circ$$



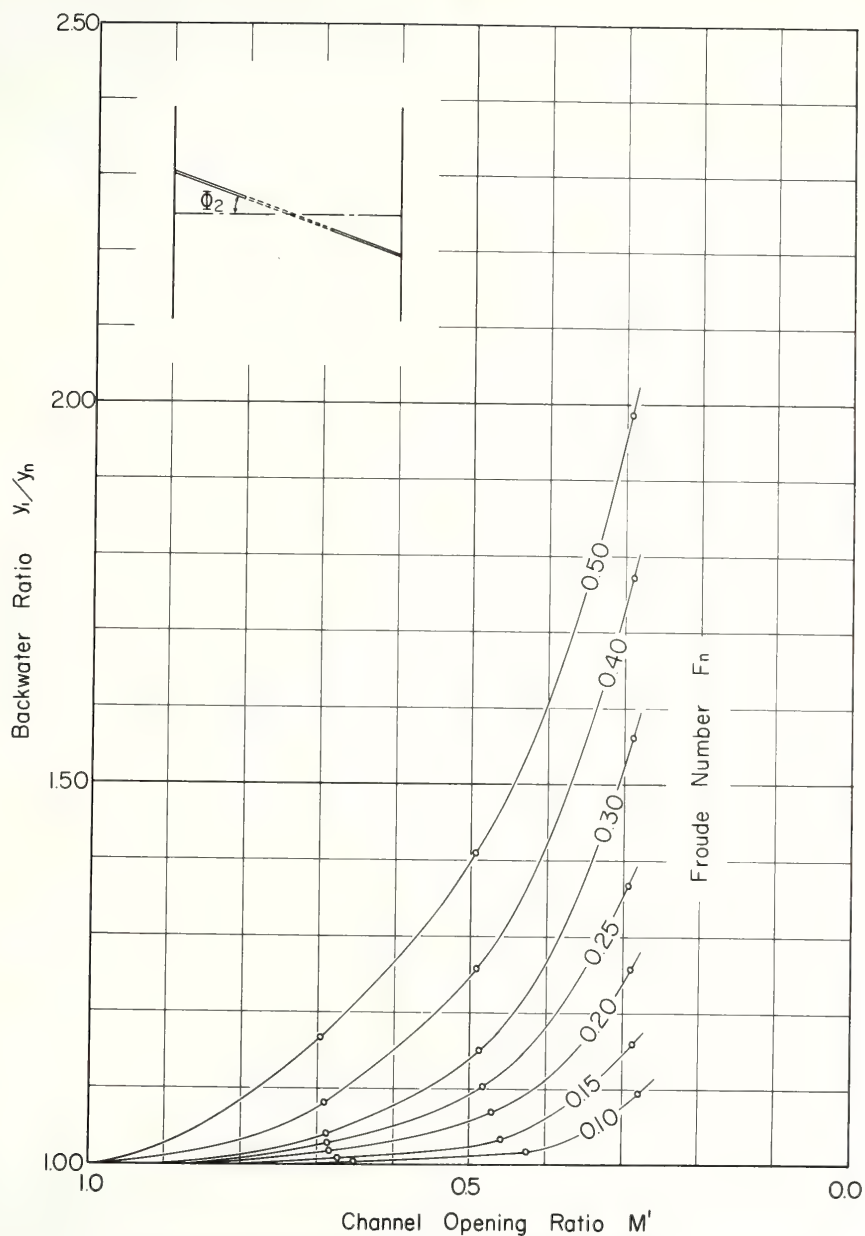


FIG. 7-6-4-BACKWATER RATIO FOR SKEW ARCH BRIDGES

$$\Phi_2 = 45^\circ$$



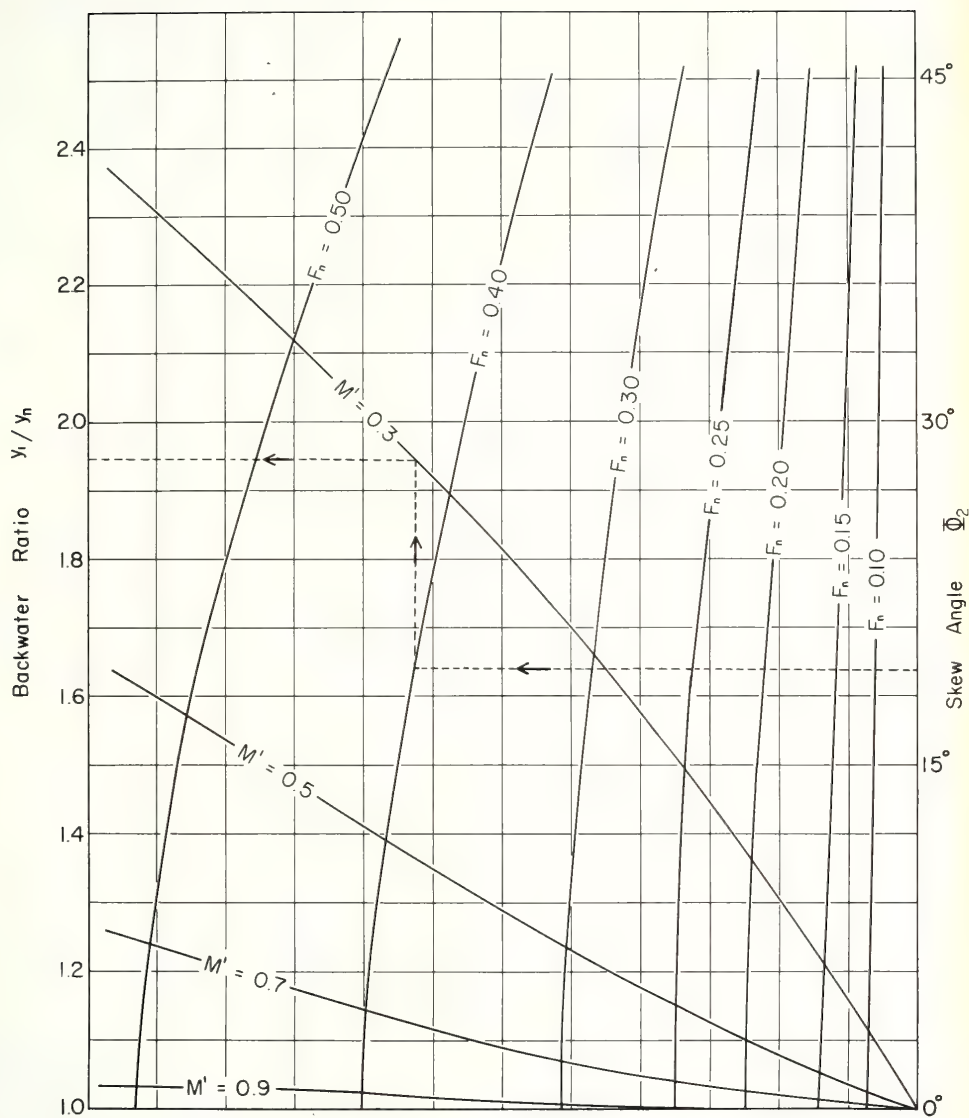


FIG. 7-6-5-BACKWATER RATIO FOR SKEW ARCH BRIDGE





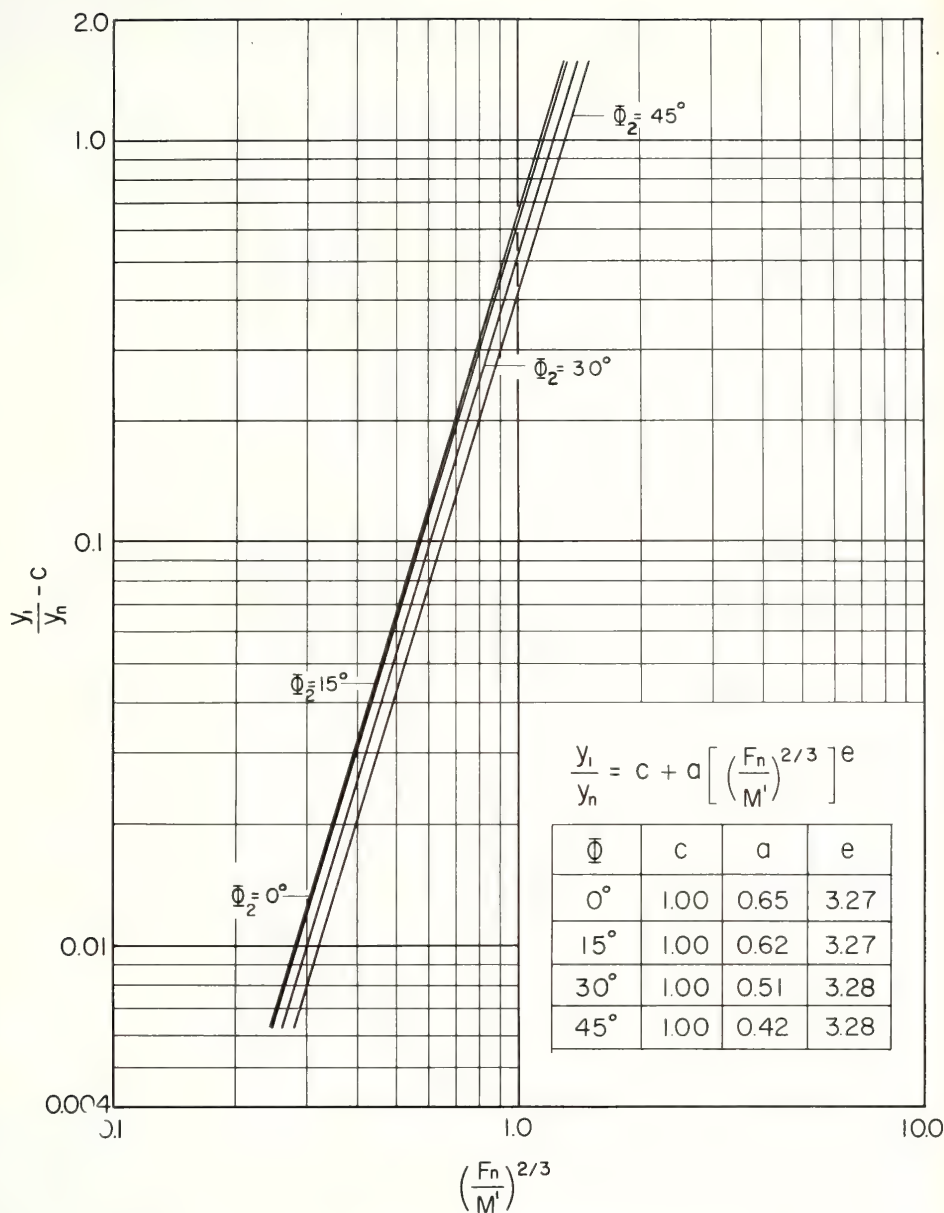


FIG. 7-6-6 - GENERALIZED BACKWATER RATIO  
FOR SKEW ARCH BRIDGE



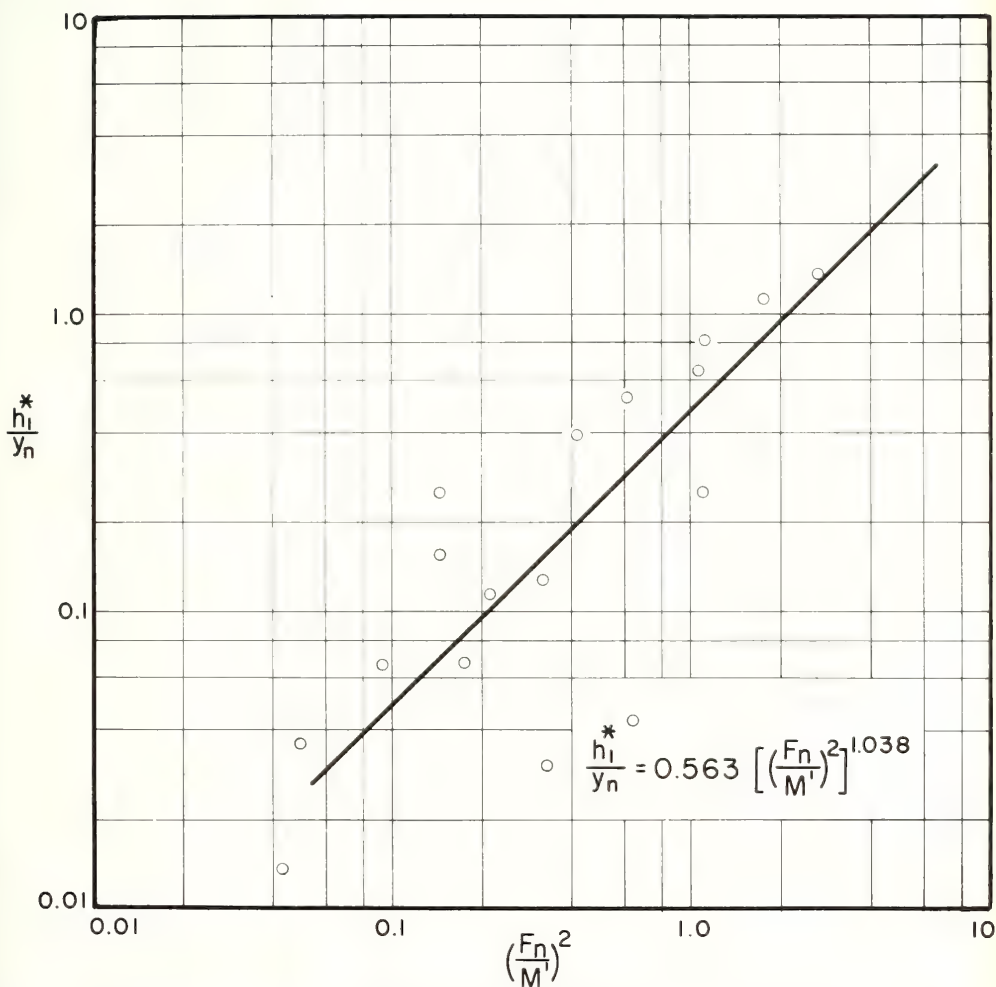


FIGURE 7-6-7 BACKWATER RATIO, GEOMETRY  $\nabla_a$   
ROUGH BOUNDARY  $\Phi_2 = 0.00$



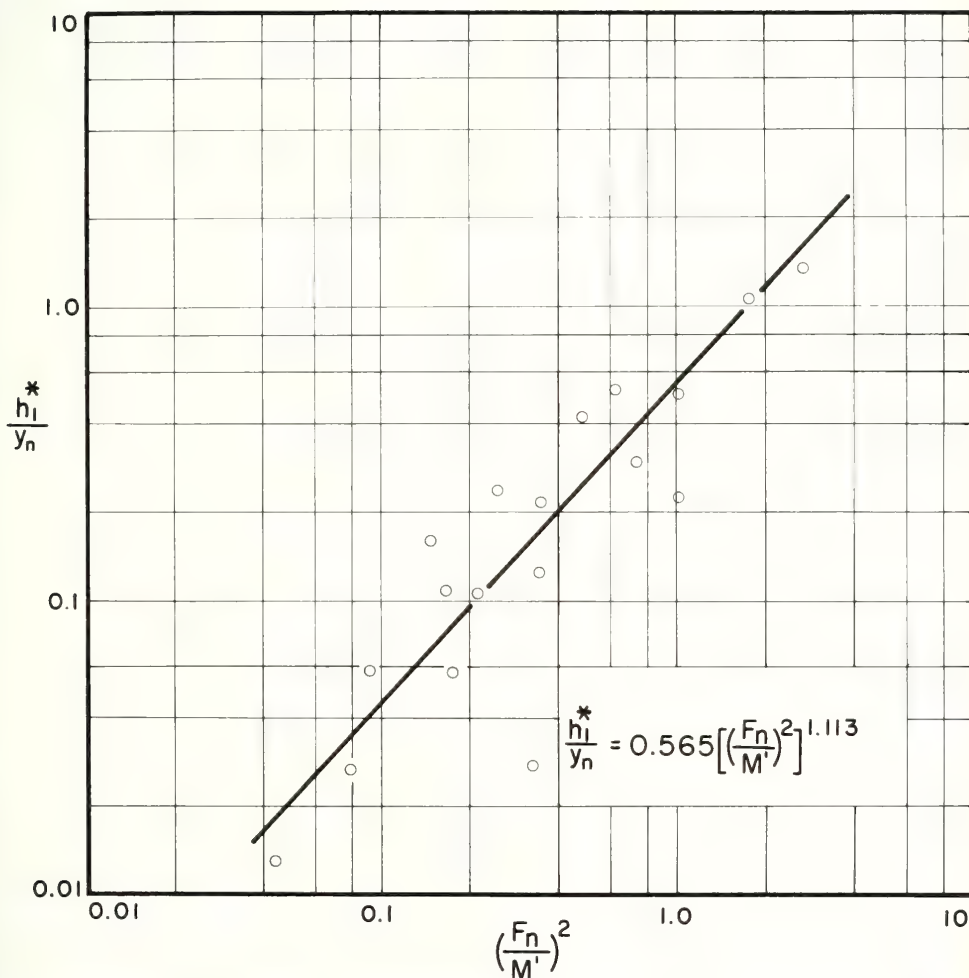


FIGURE 7-6-8 BACKWATER RATIO, GEOMETRY  $\nabla_a$   
ROUGH BOUNDARY  $\Phi_2 = 15^\circ$



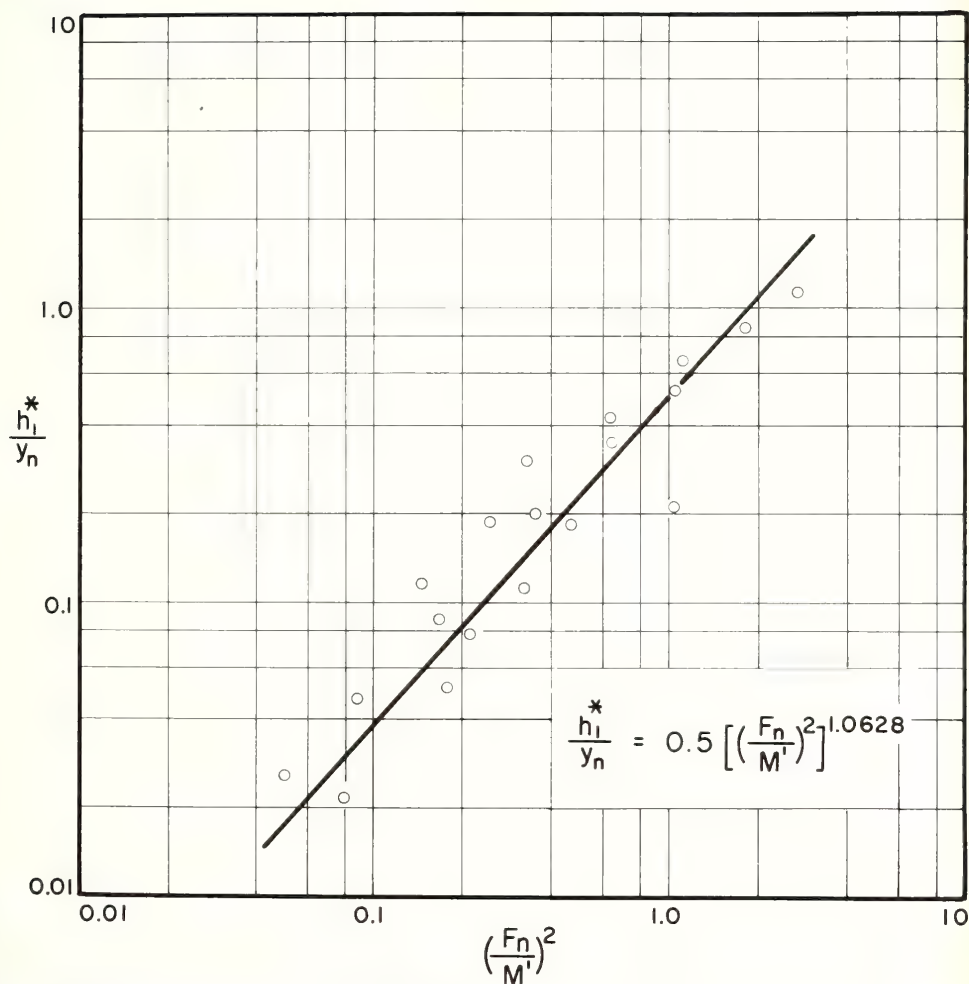


FIGURE 7-6-9 BACKWATER RATIO, GEOMETRY  $V_0$   
ROUGH BOUNDARY  $\Phi_2 = 30^\circ$





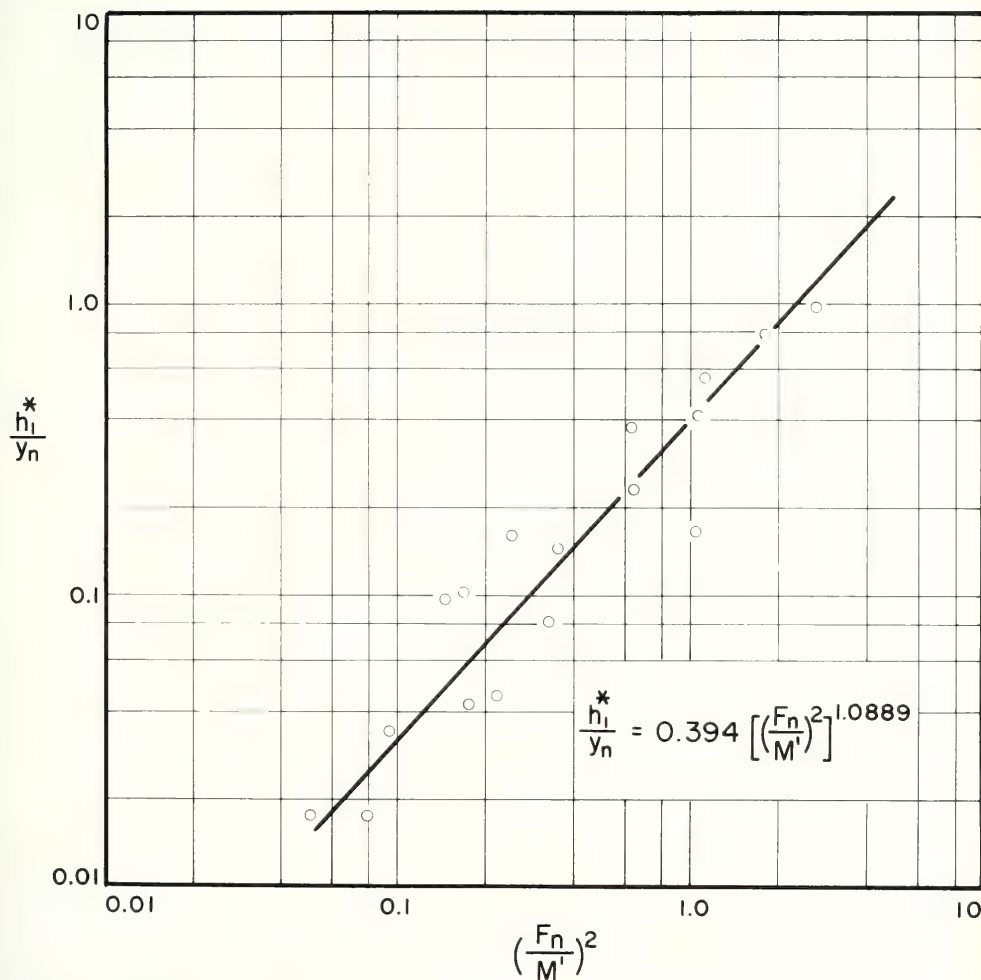


FIGURE 7-6-10 BACKWATER RATIO, GEOMETRY  $\nabla_d$

ROUGH BOUNDARY  $\Phi_2 = 45^\circ$



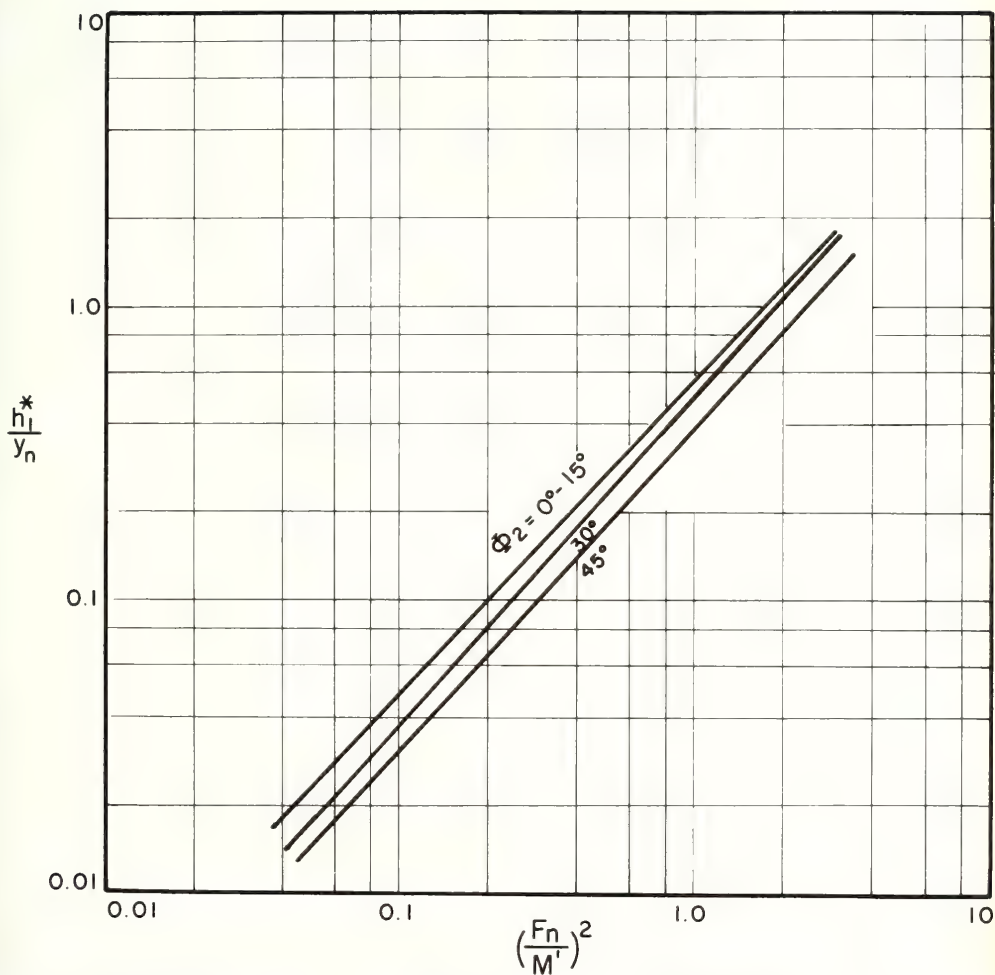


FIGURE 7-6-II SUMMARY OF BACKWATER RATIO  
GEOMETRY  $\nabla_0$  ROUGH BOUNDARY



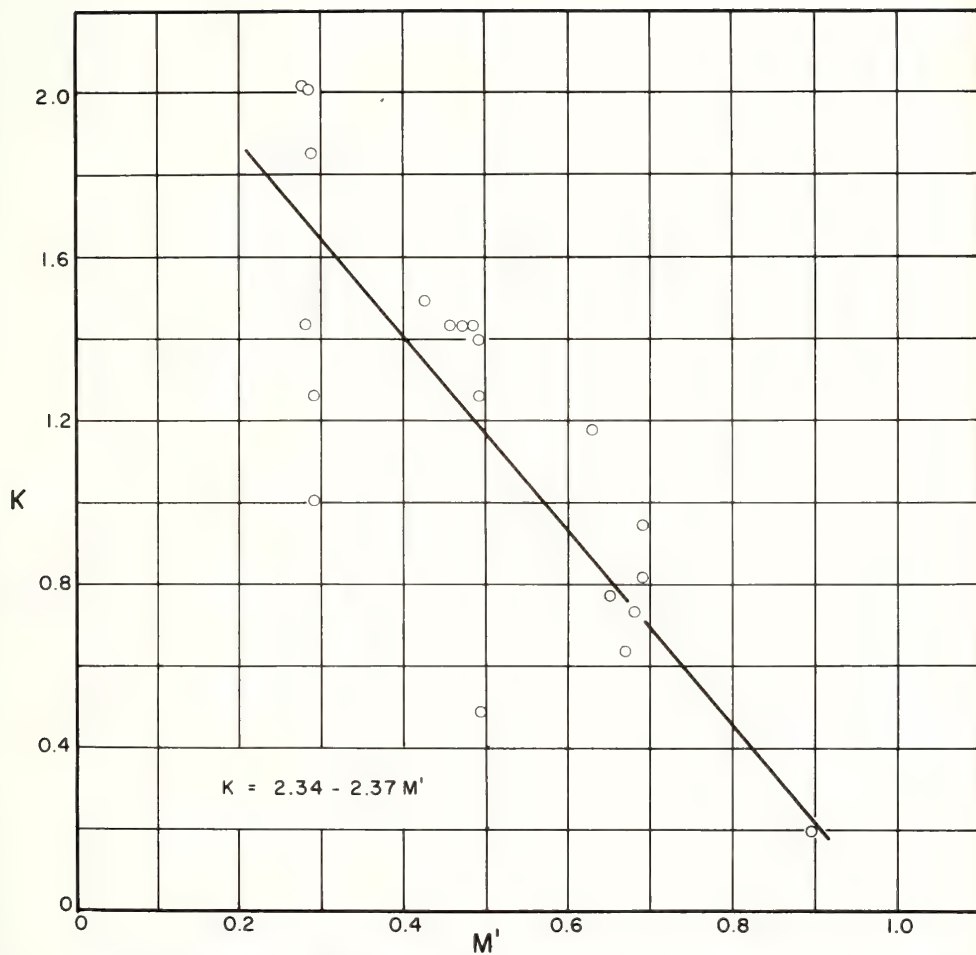


FIGURE 7-6-12 HEAD LOSS COEFFICIENT, GEOMETRY  $\nabla_0$   
ROUGH BOUNDARY  $\Phi_2 = 0.0^\circ$



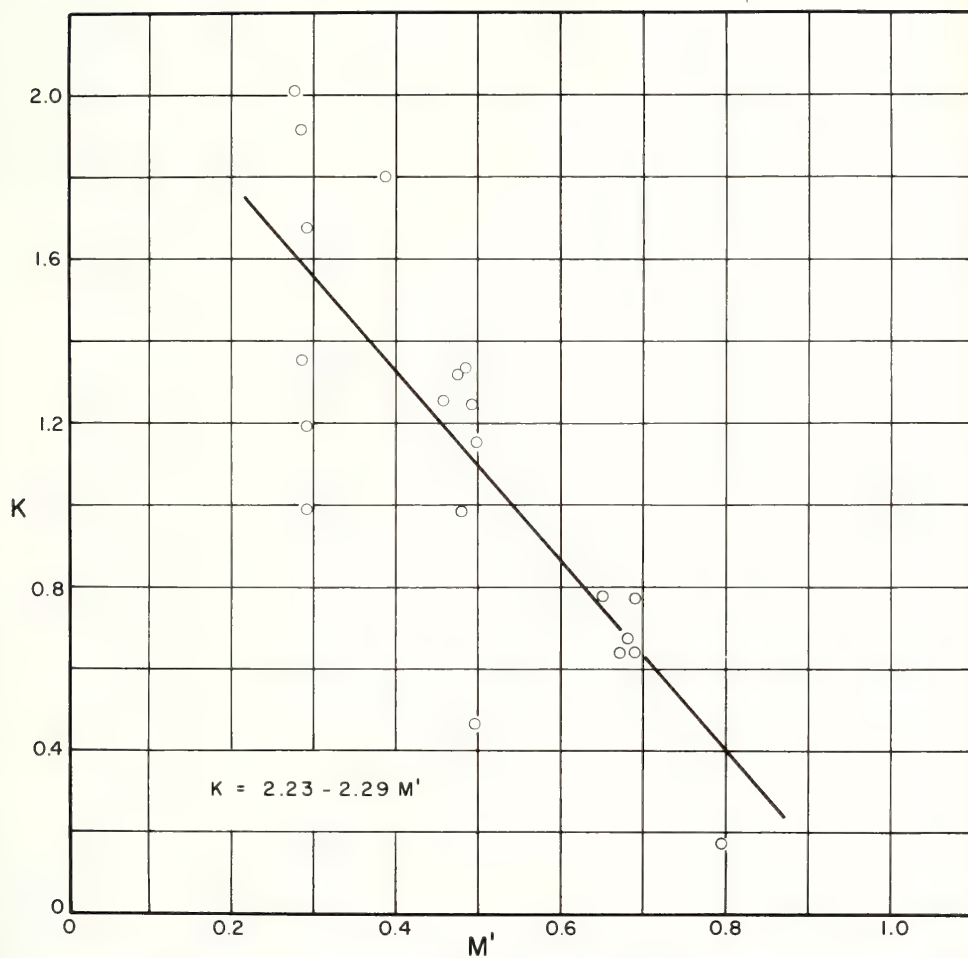


FIGURE 7-6-13 HEAD LOSS COEFFICIENT, GEOMETRY  $\nabla_0$   
ROUGH BOUNDARY  $\Phi_2 = 15^\circ$





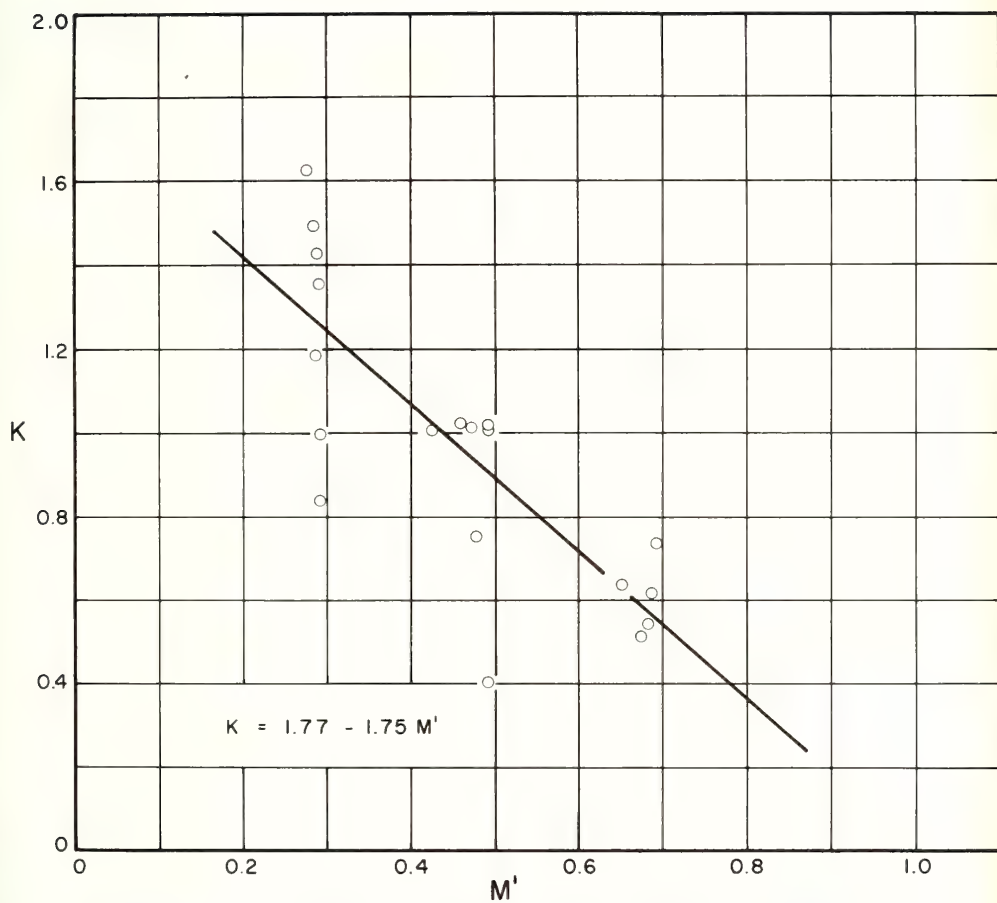


FIGURE 7-6-14 HEAD LOSS COEFFICIENT, GEOMETRY  $\nabla_0$   
ROUGH BOUNDARY  $\Phi_2 = 30^\circ$



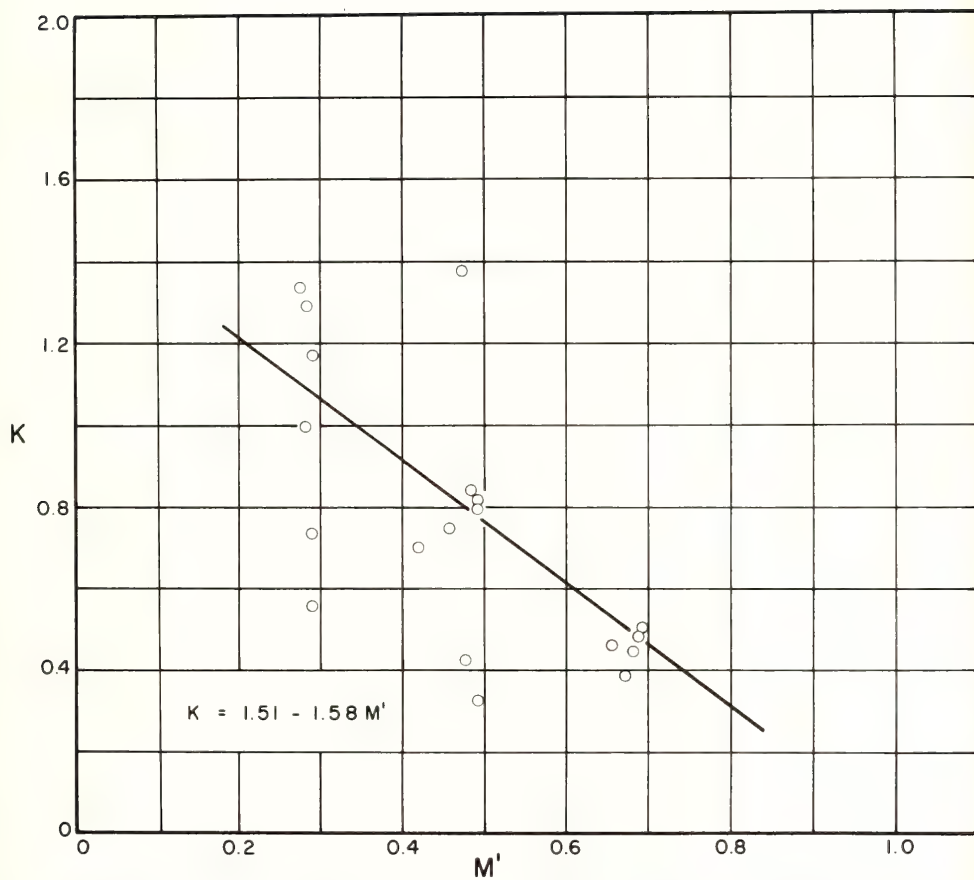


FIGURE 7-6-15 HEAD LOSS COEFFICIENT, GEOMETRY  $\nabla_0$   
ROUGH BOUNDARY  $\Phi_2 = 45^\circ$



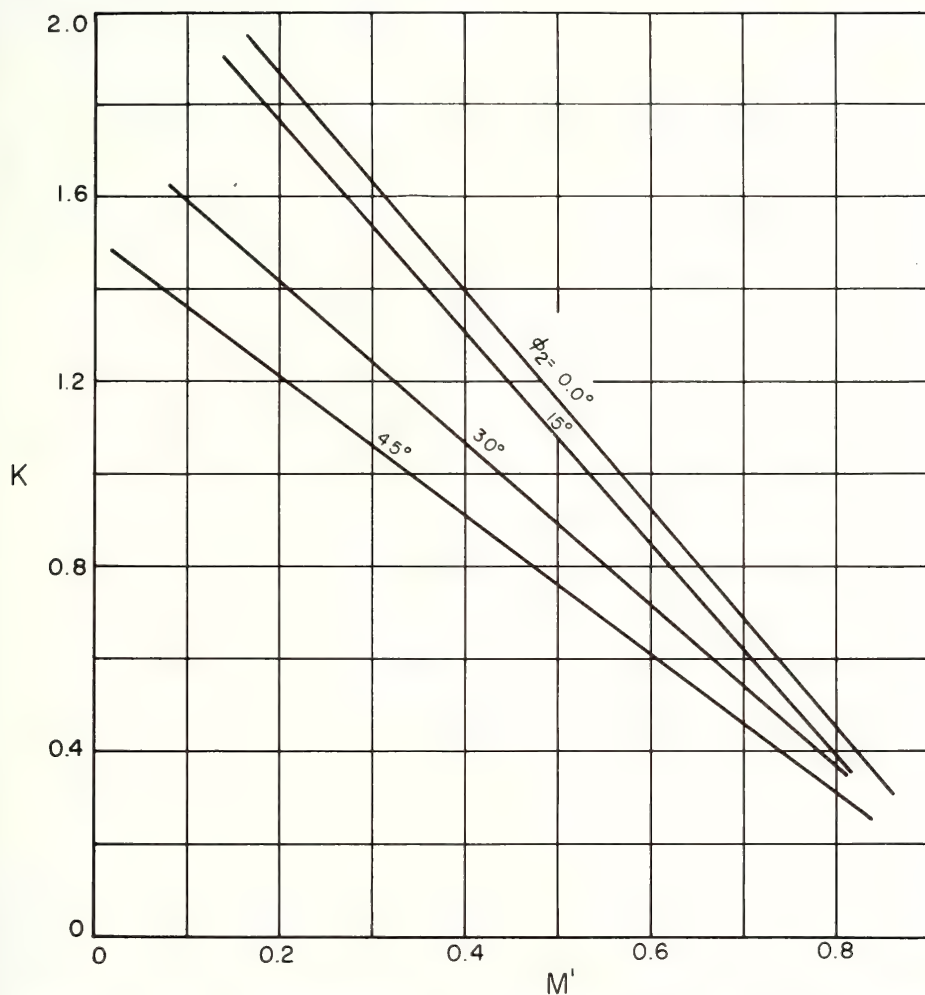


FIGURE 7-6-16 SUMMARY OF HEAD LOSS COEFFICIENTS  
GEOMETRY  $\nabla_0$ . ROUGH BOUNDARIES



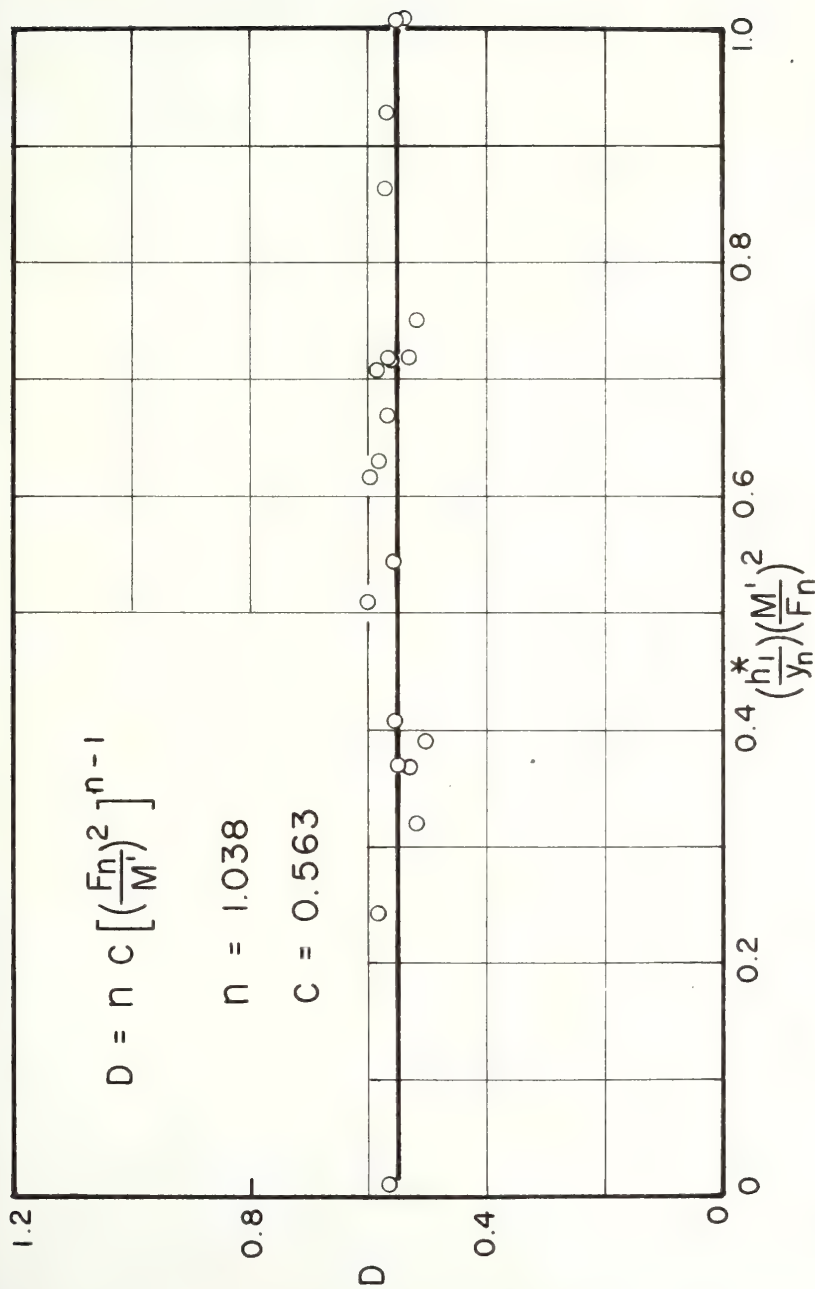


FIGURE 7-6-17 BACKWATER RATIO COEFFICIENT, GEO -  
METRY  $V_a$  ROUGH BOUNDARY  $\Phi_2 = 0.0$





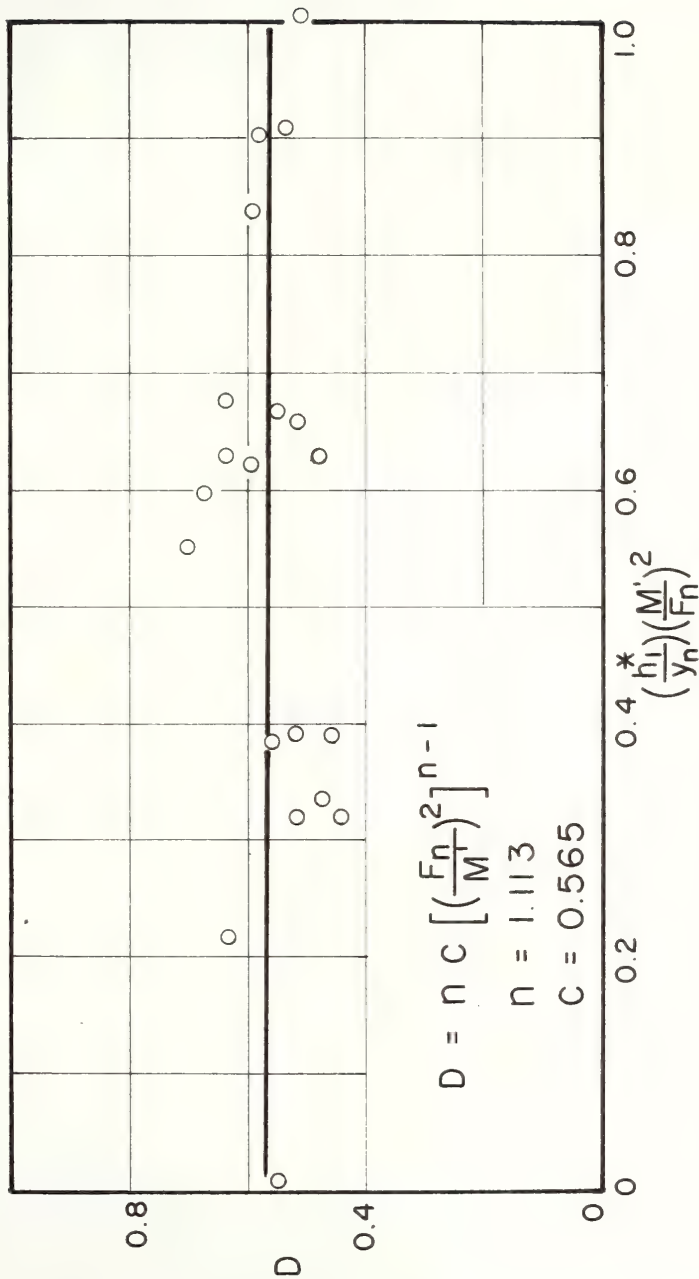


FIGURE 7-6-18 BACKWATER RATIO COEFFICIENT, GEO -

METRY  $V_a$  ROUGH BOUNDARY  $\Phi_2 = 15^\circ$



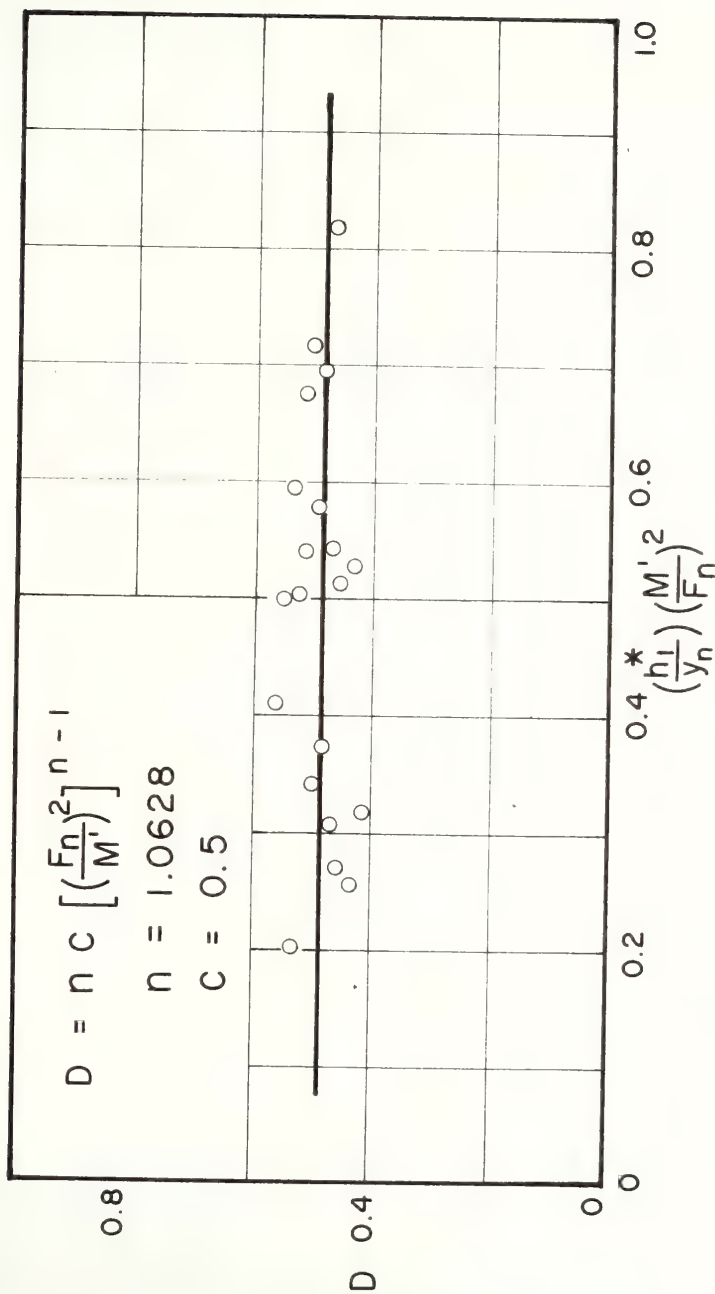


FIGURE 7-6-19 BACKWATER RATIO COEFFICIENT, GEO -  
METRY  $V_q$  ROUGH BOUNDARY  $\Phi_2 = 30^\circ$



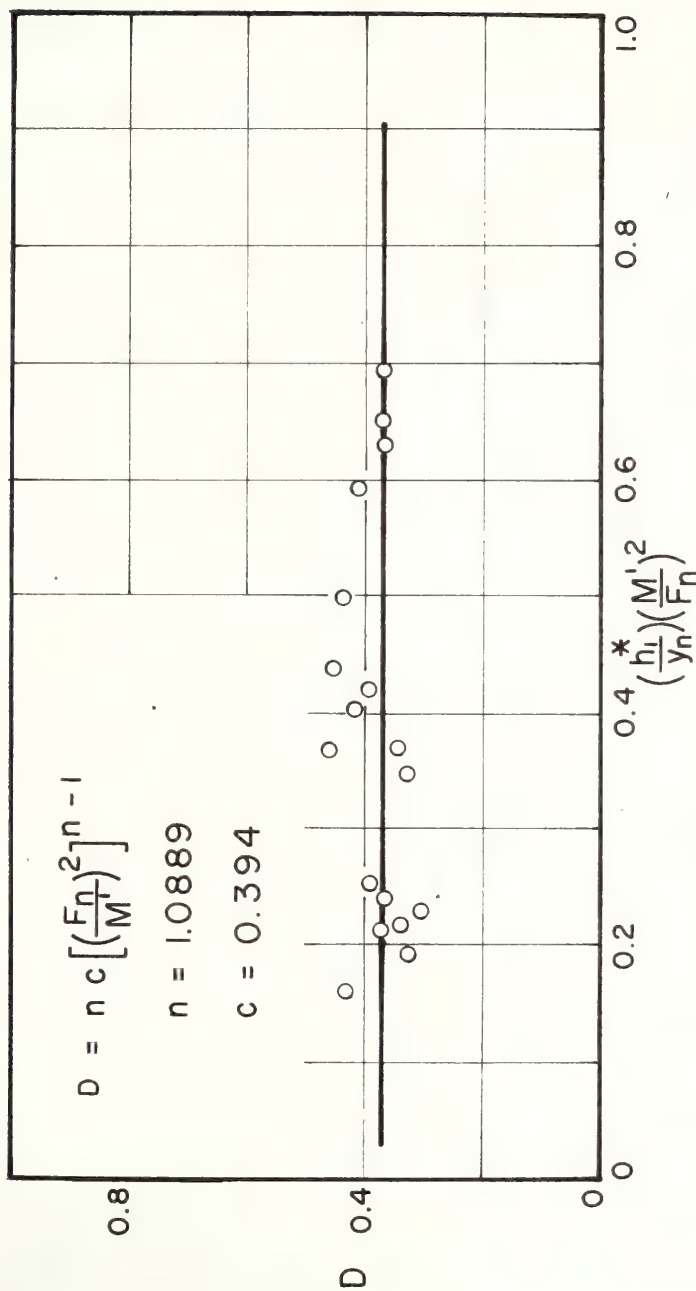


FIGURE 7-6-20 BACKWATER RATIO COEFFICIENT, GEOMETRY  $V_a$  ROUGH BOUNDARY  $\Phi_2 = 45^\circ$



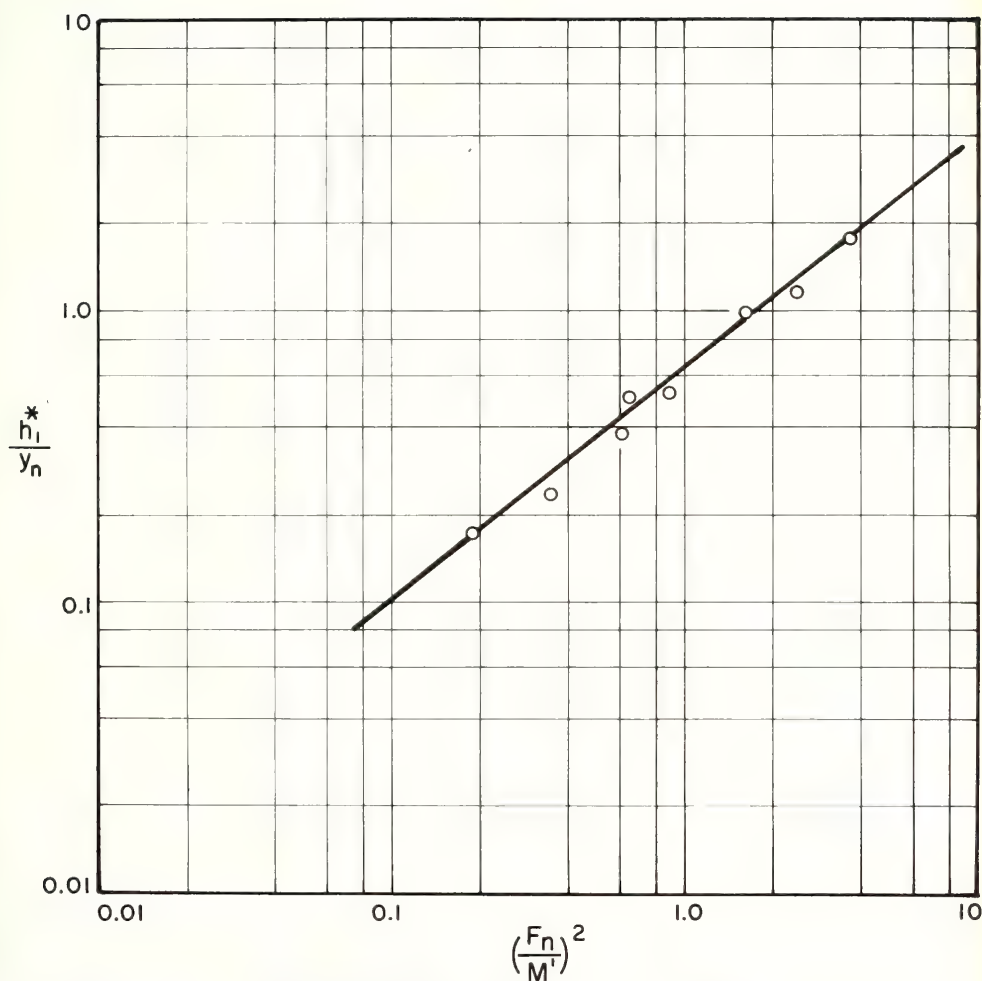


FIGURE 7-7-1 BACKWATER RATIO, GEOMETRY  $\nabla_b$   
ROUGH BOUNDARY  $\Phi_2 = 15^\circ$





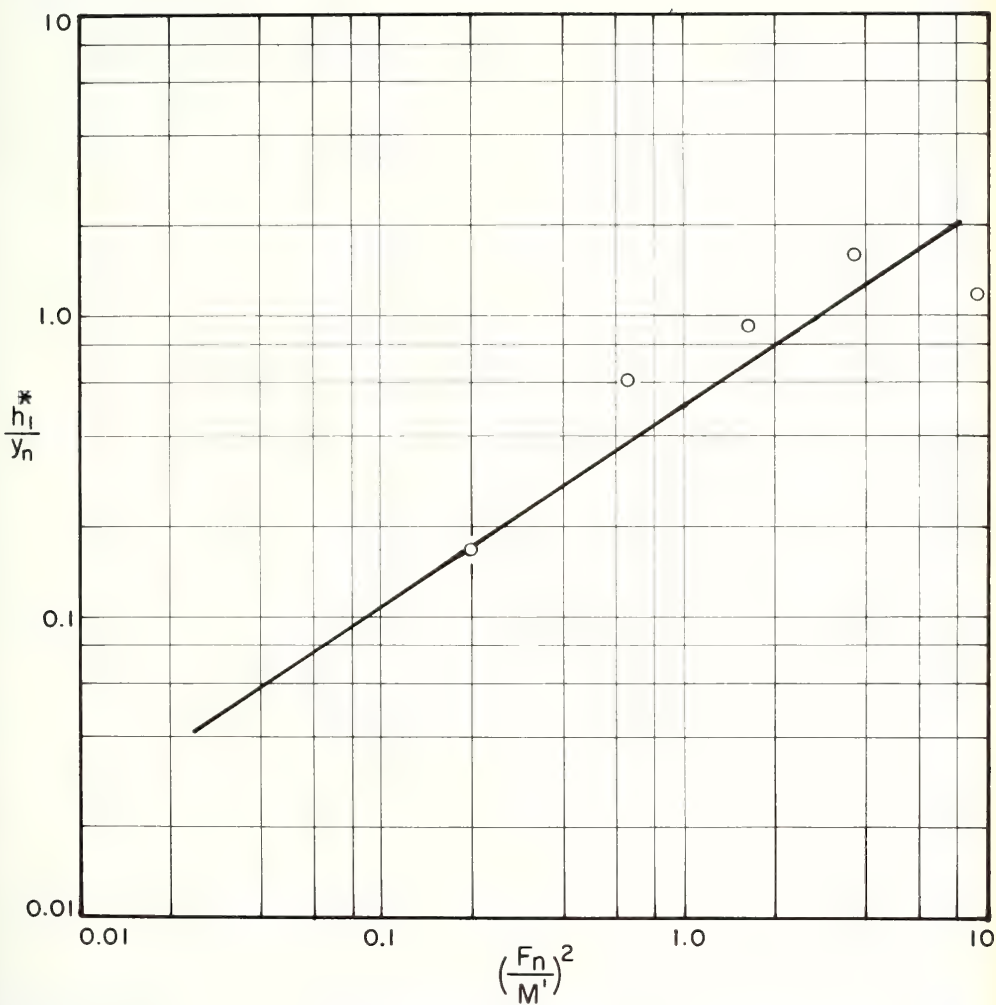


FIGURE 7-7-2 BACKWATER RATIO, GEOMETRY  $\nabla_b$   
ROUGH BOUNDARY  $\Phi_2 = 30^\circ$



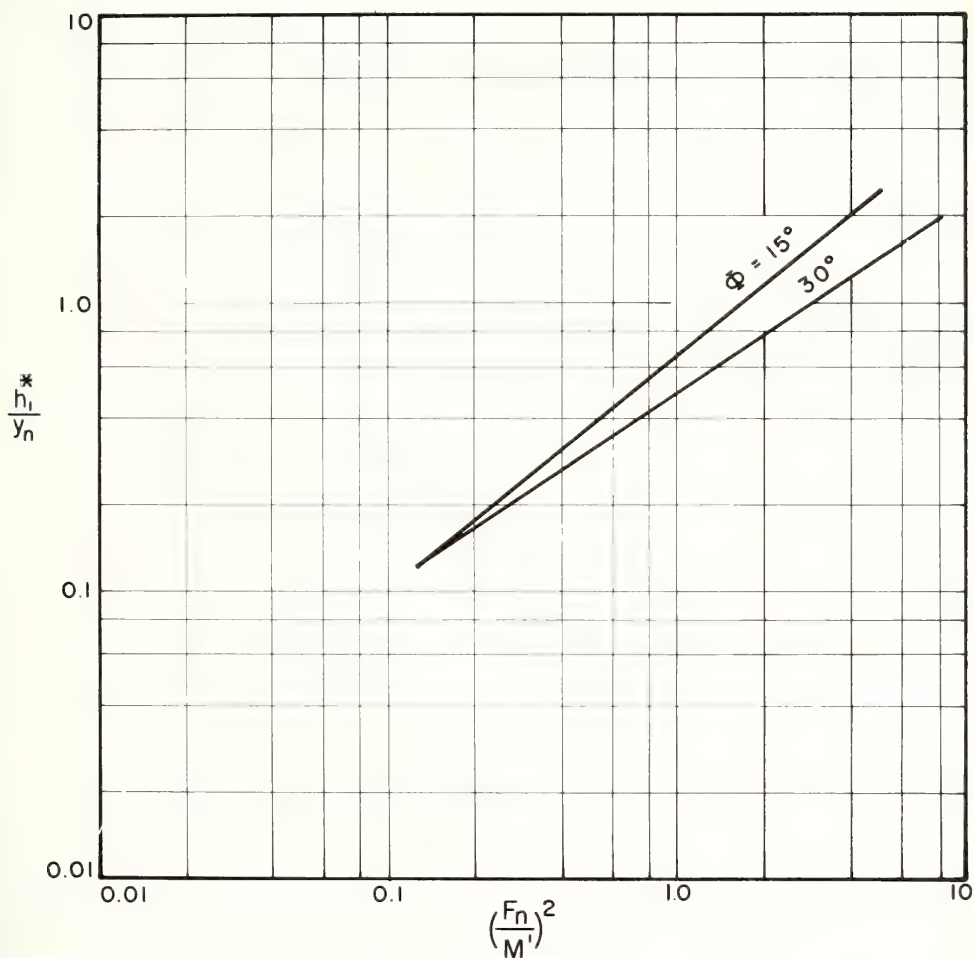


FIGURE 7-7-3 SUMMARY OF BACKWATER RATIO, GEOMETRY  $\nabla_b$  ROUGH BOUNDARY



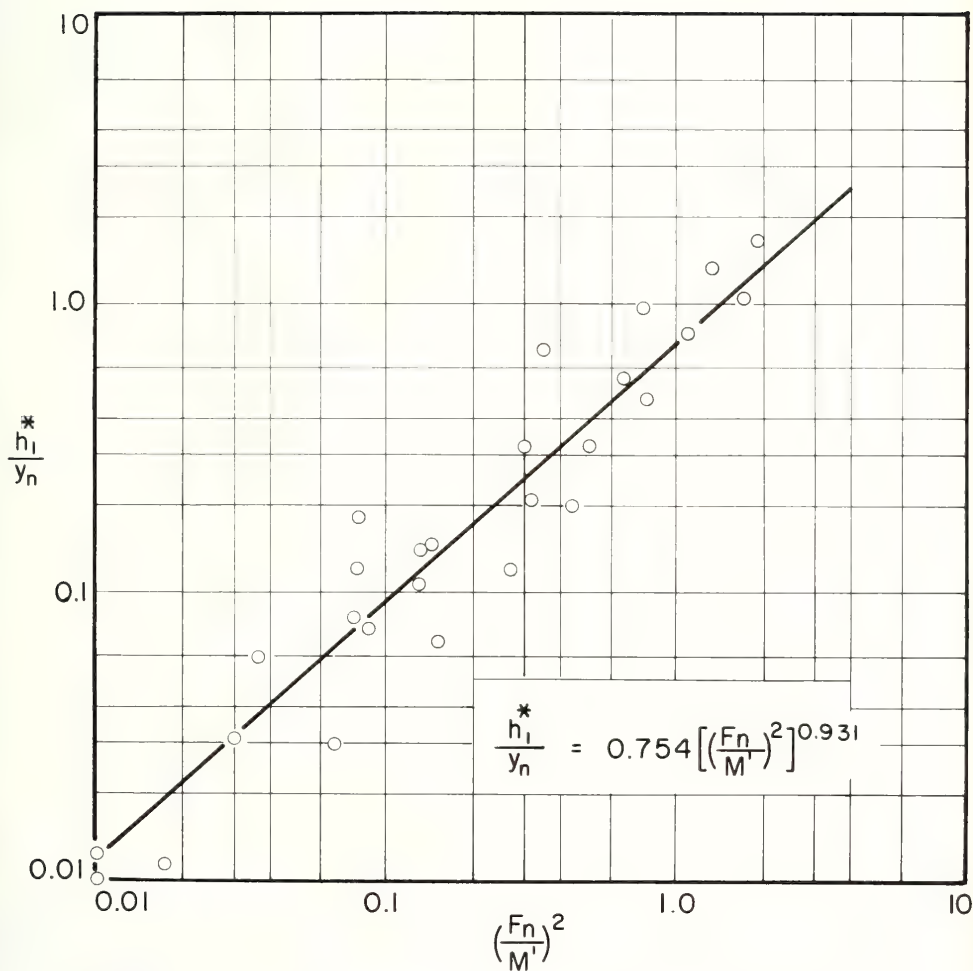


FIGURE 7-8-1 BACKWATER RATIO, GEOMETRY VI  
ROUGH BOUNDARY



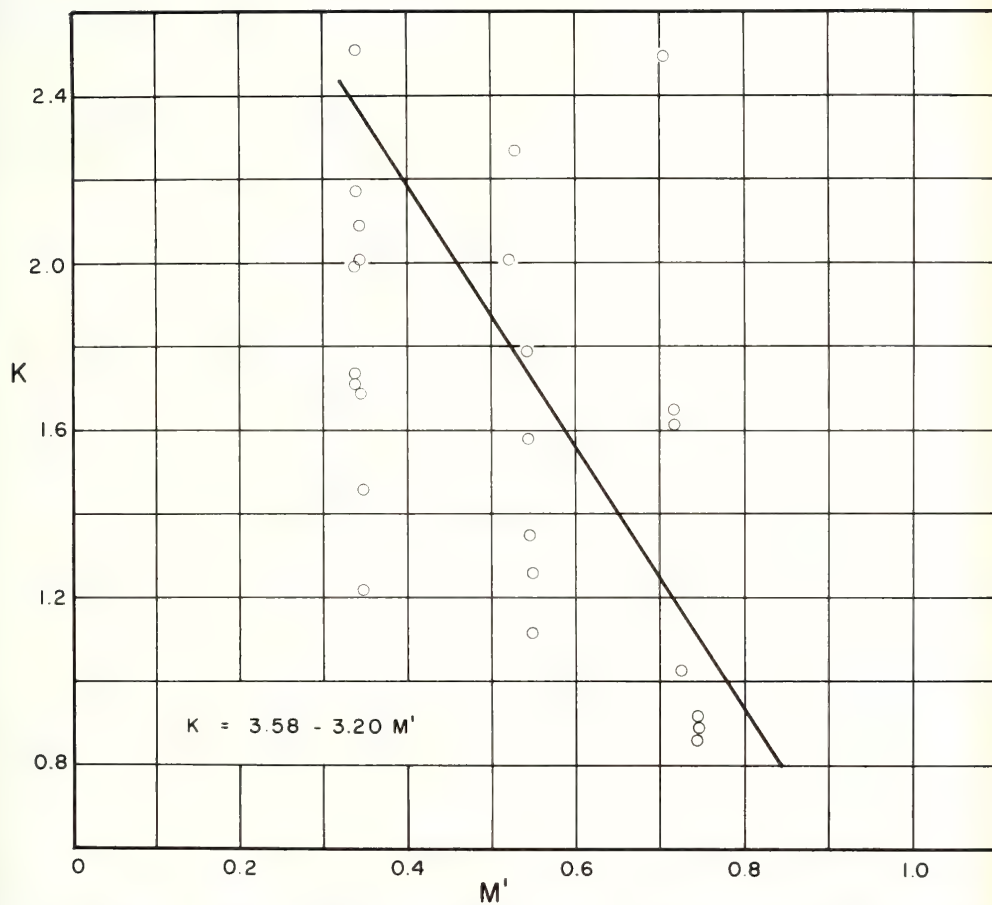


FIGURE 7-8-2 HEAD LOSS COEFFICIENT, GEOMETRY VII  
ROUGH BOUNDARY





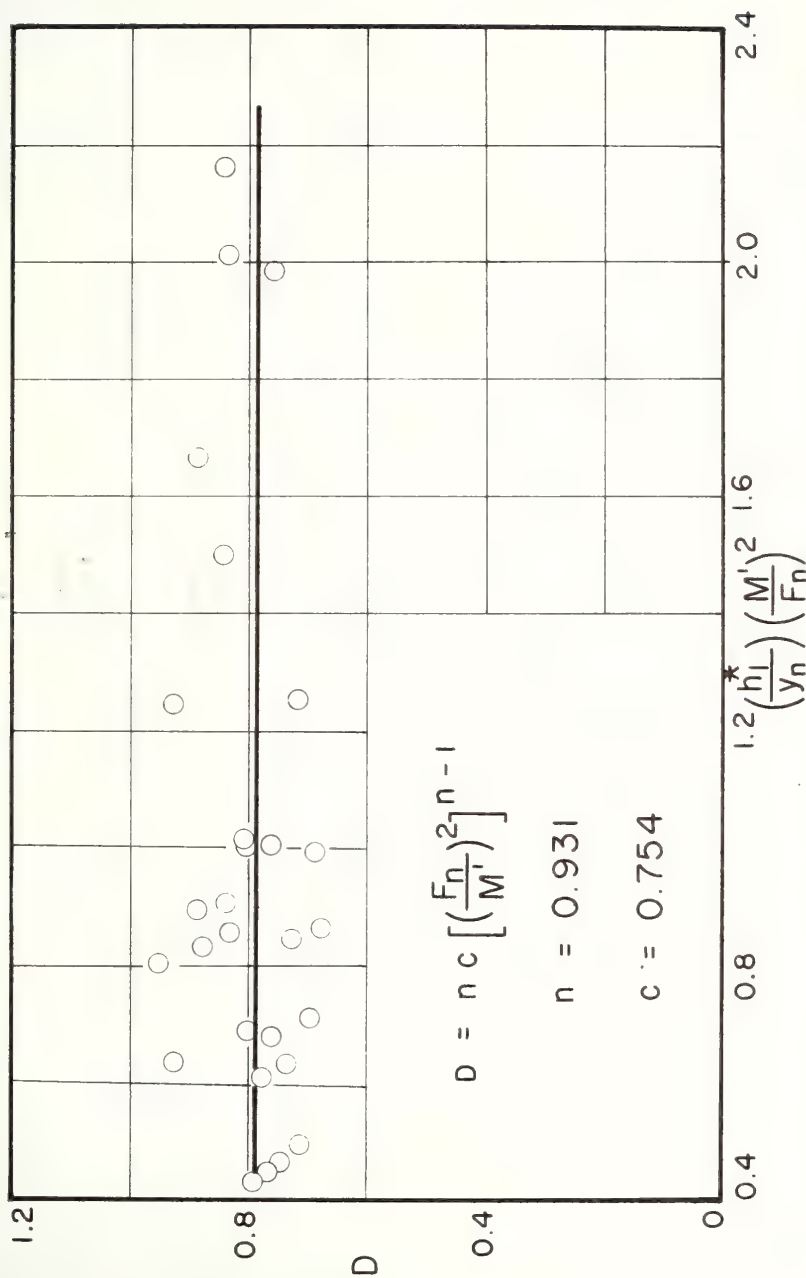


FIGURE 7-8-3 BACKWATER RATIO COEFFICIENT, GEOMETRY VI ROUGH BOUNDARY



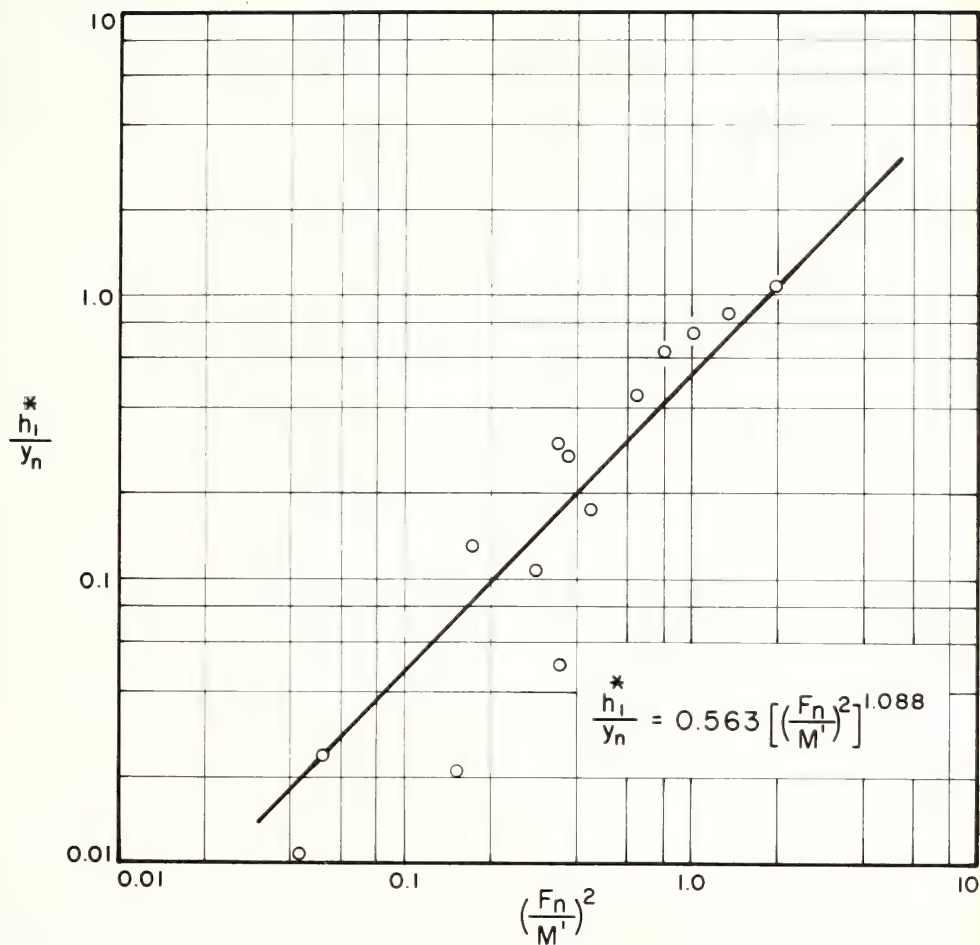


FIGURE 7-9-1 BACKWATER RATIO , GEOMETRY VII  
ROUGH BOUNDARY  $\beta = 0.00$



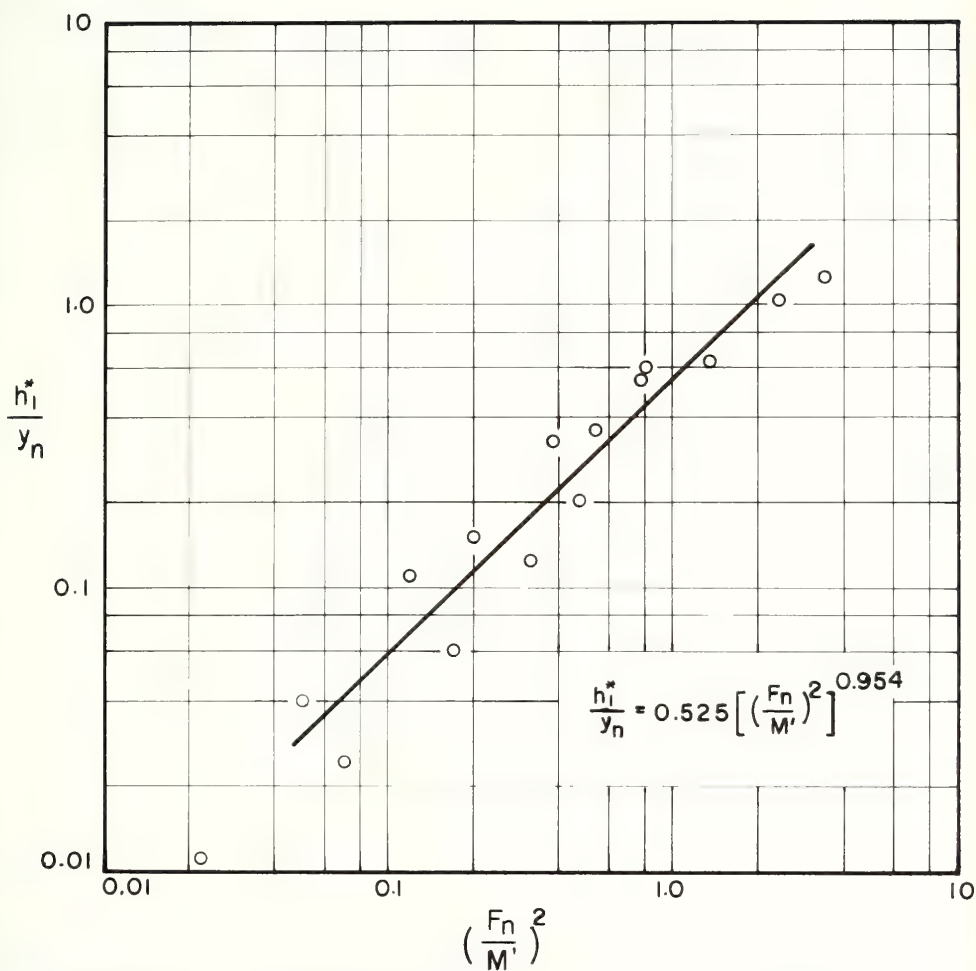


FIGURE 7-9-2 BACKWATER RATIO, GEOMETRY VII  
ROUGH BOUNDARY  $\beta = 0.3$



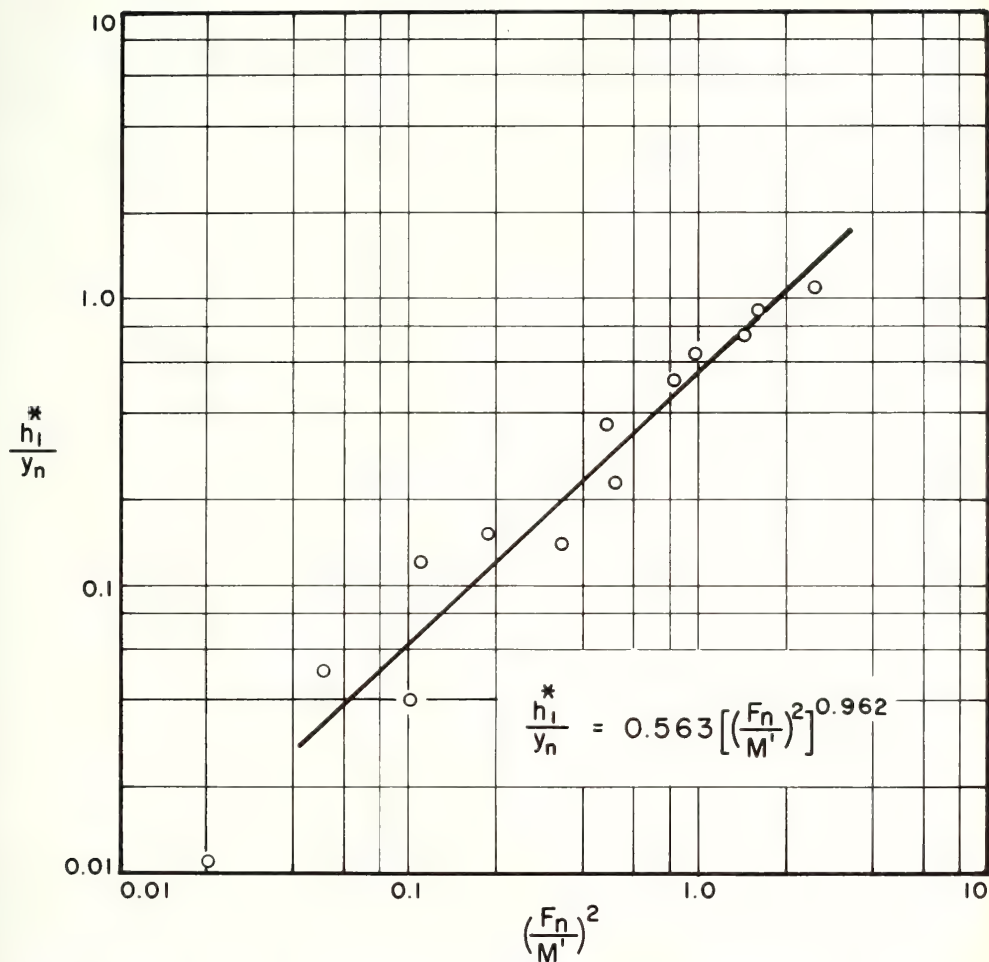


FIGURE 7-9-3 BACKWATER RATIO , GEOMETRY VII  
ROUGH BOUNDARIES  $\beta = 0.5$





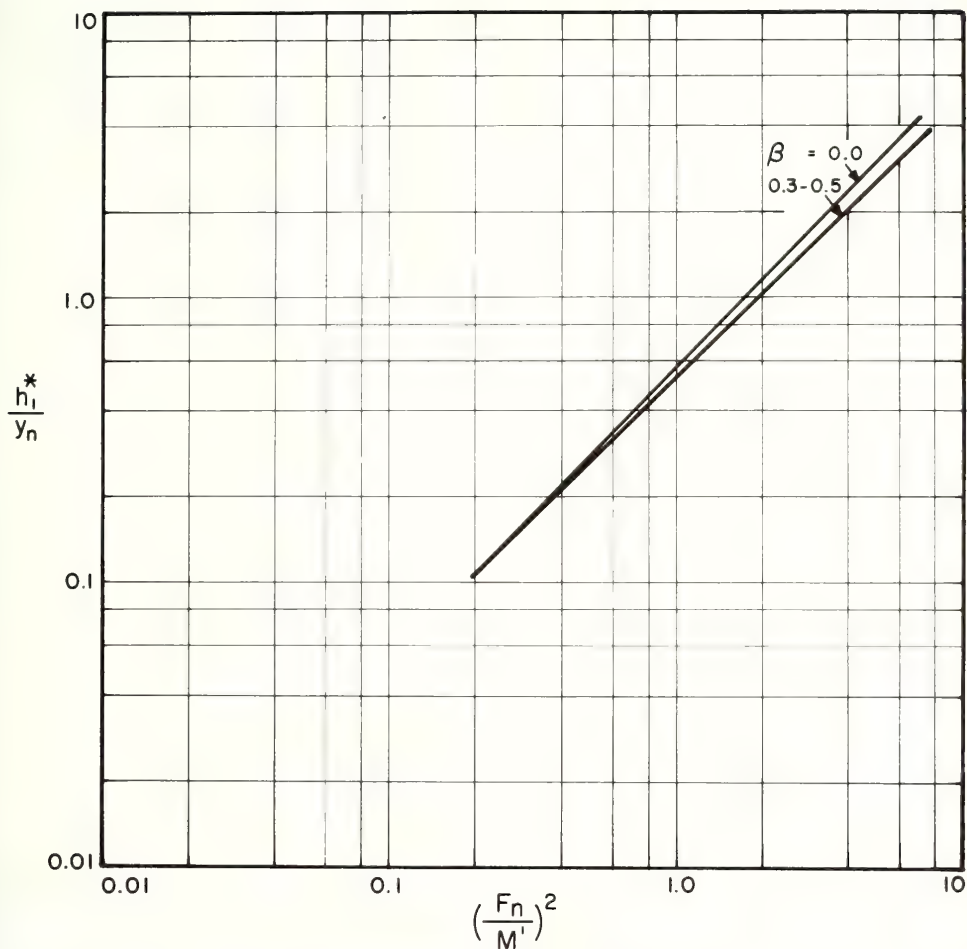


FIGURE 7-9-4 SUMMARY OF BACKWATER RATIO, GEOMETRY VII, ROUGH BOUNDARIES



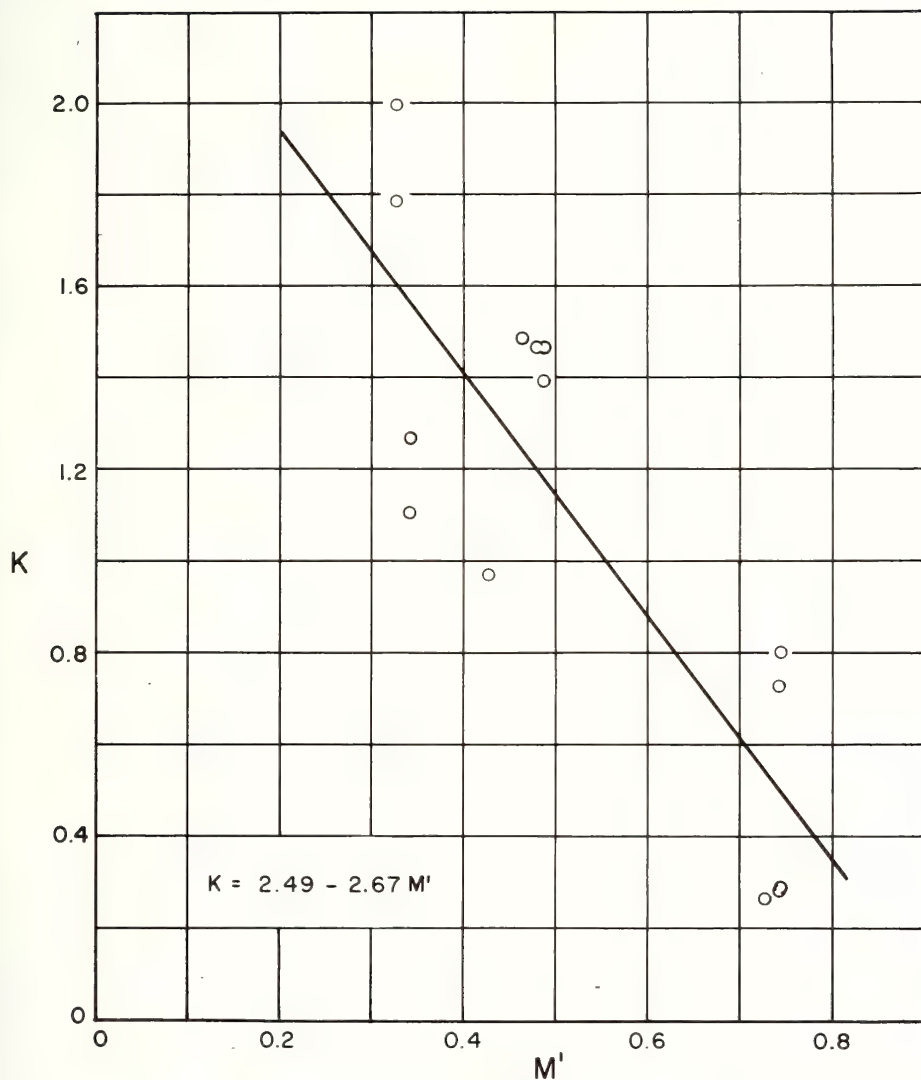


FIGURE 7-9-5 HEAD LOSS COEFFICIENT, GEOMETRY VII  
ROUGH BOUNDARY,  $\beta = 0.00$



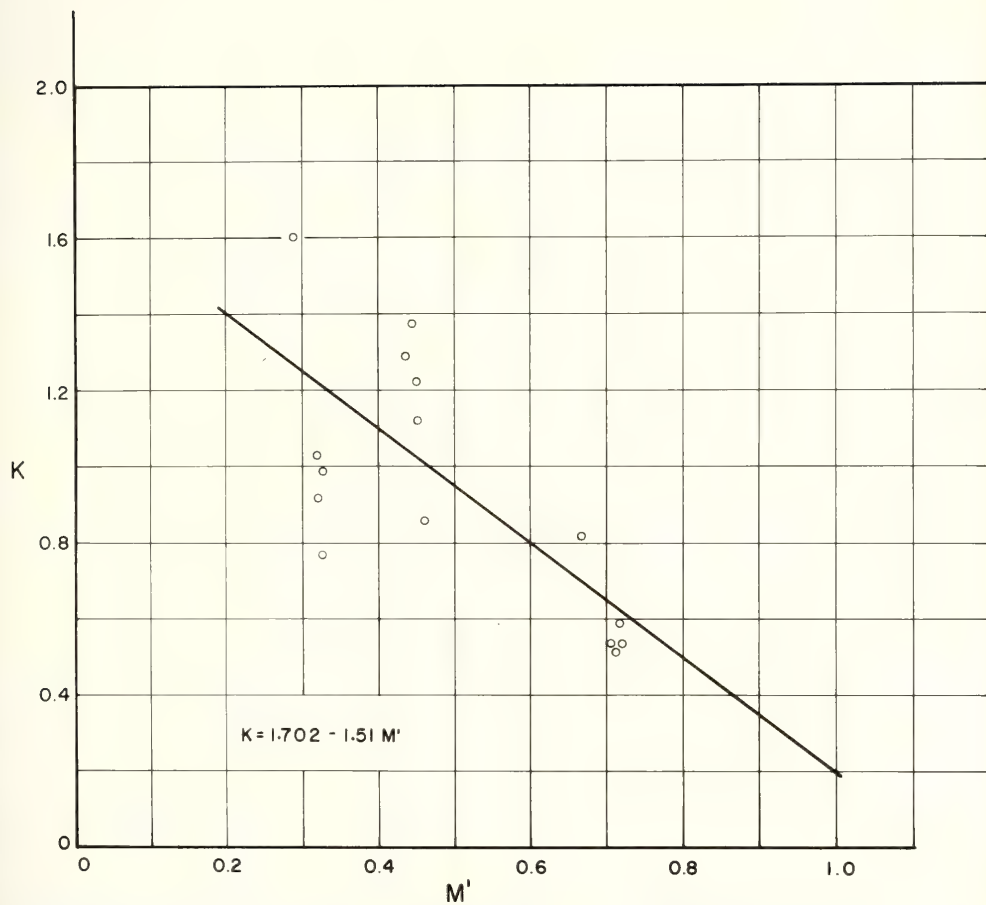


FIGURE 7-9-6 HEAD LOSS COEFFICIENT, GEOMETRY VII  
ROUGH BOUNDARY,  $\beta = 0.3$



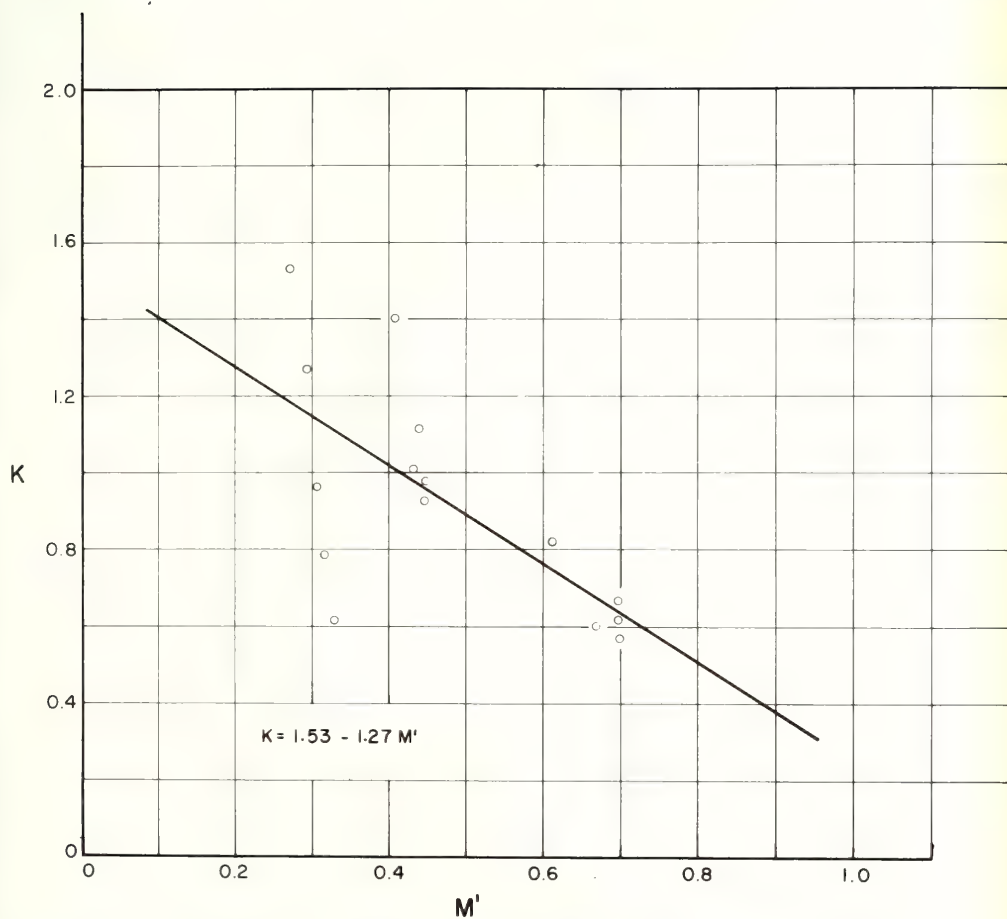


FIGURE 7-9-7 HEAD LOSS COEFFICIENT, GEOMETRY VII  
ROUGH BOUNDARY,  $\beta = 0.5$





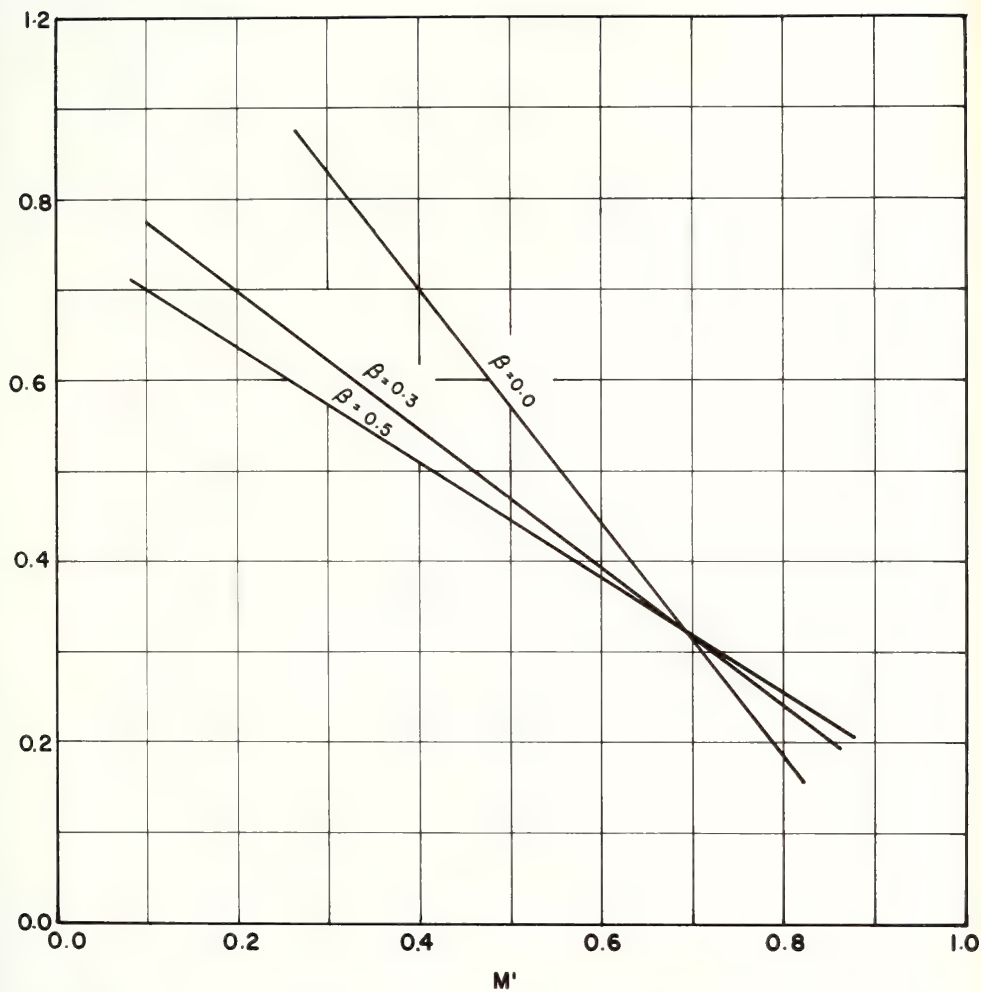


FIGURE 7-9-8 SUMMARY OF HEAD LOSS COEFFICIENT  
GEOMETRY VII ROUGH BOUNDARY



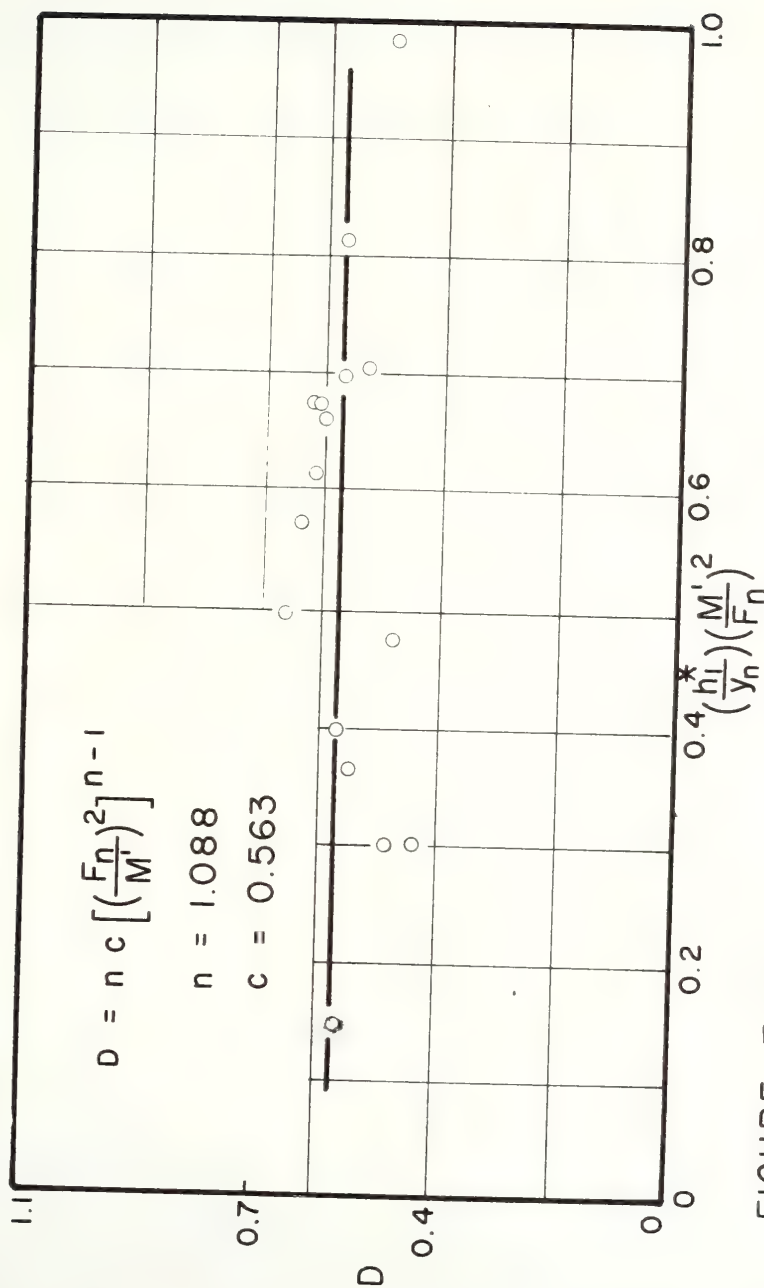


FIGURE 7-9-9 BACKWATER RATIO COEFFICIENT, GEOMETRY VII ROUGH BOUNDARY  $\beta = 0.0$



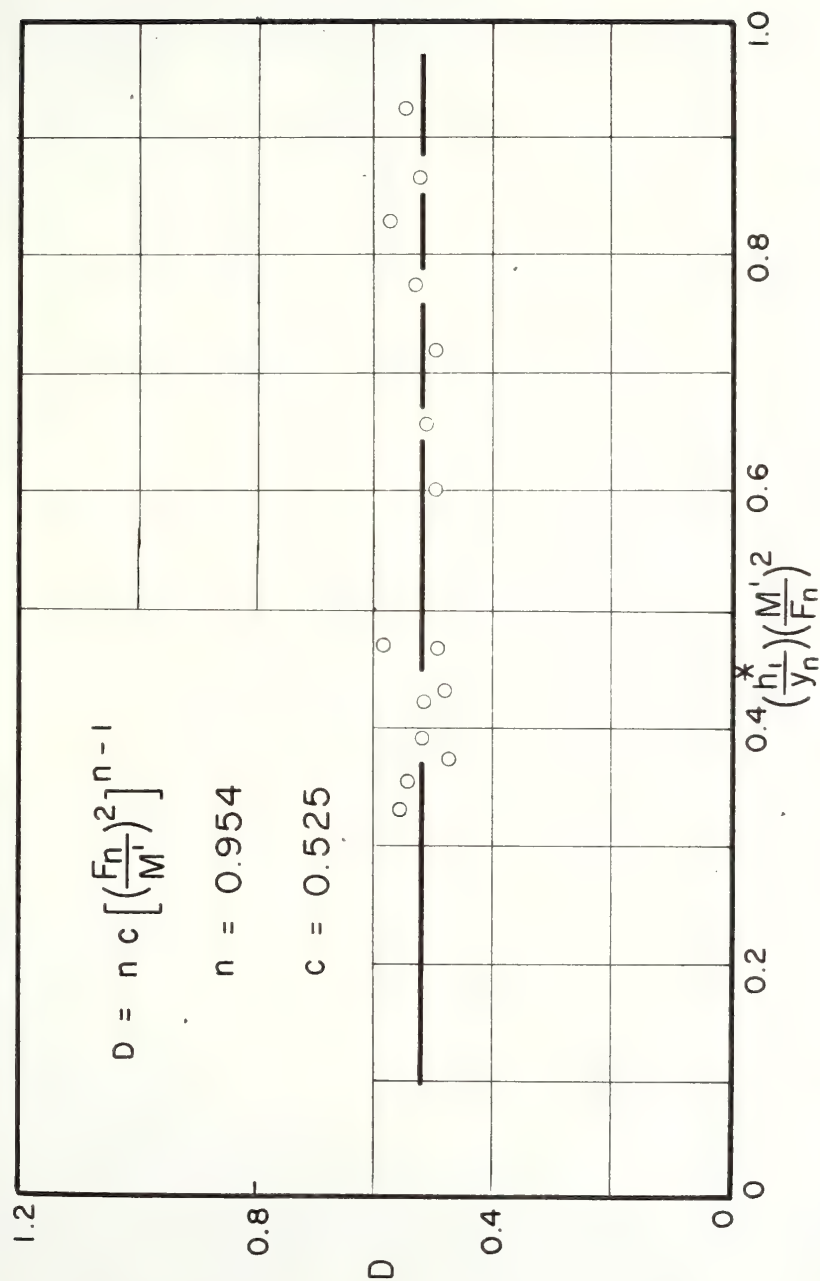


FIGURE 7-9-10 BACKWATER RATIO COEFFICIENT, GEOMETRY VII ROUGH BOUNDARY  $\beta = 0.3$



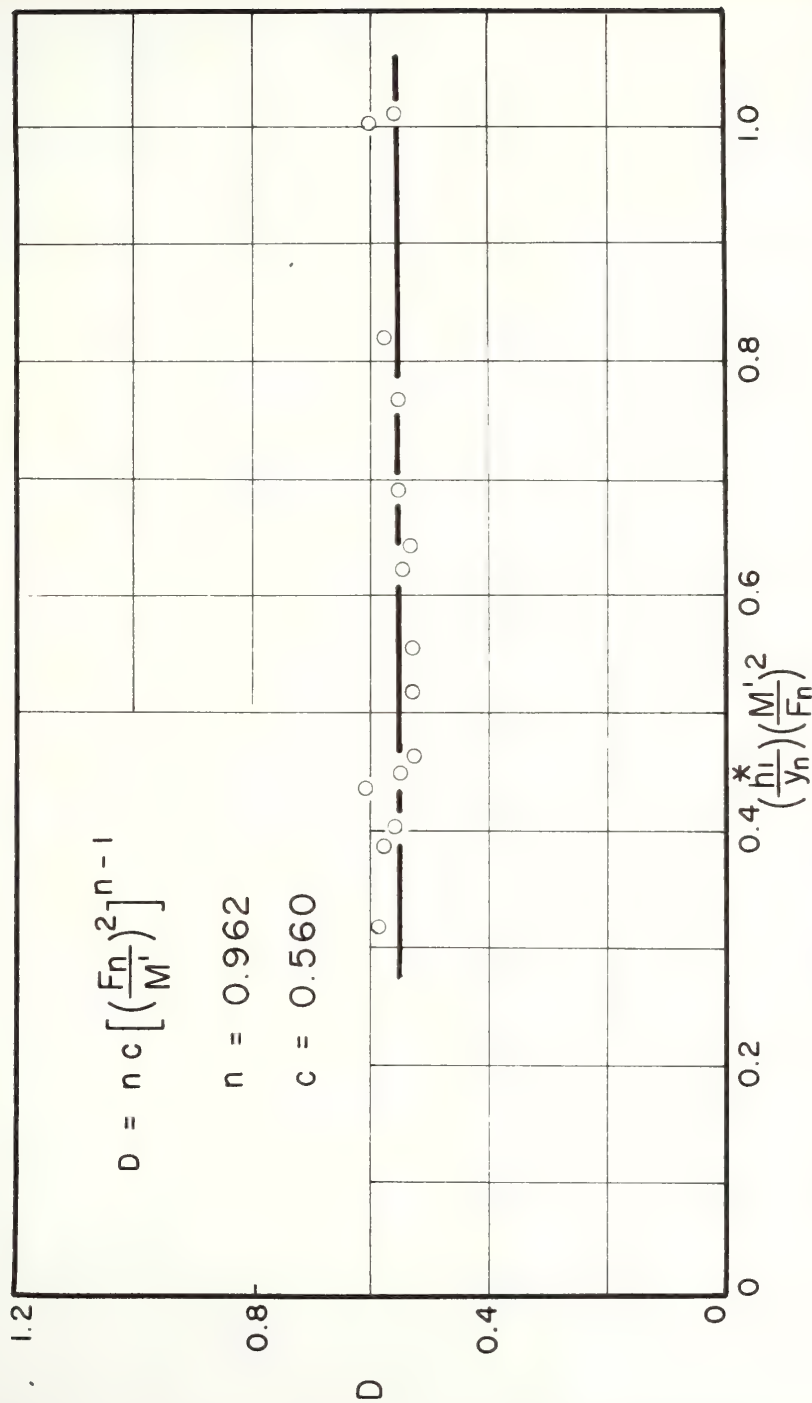


FIGURE 7-9-II BACKWATER RATIO COEFFICIENT, GEOMET-  
RY VII ROUGH BOUNDARY  $\beta = 0.5$





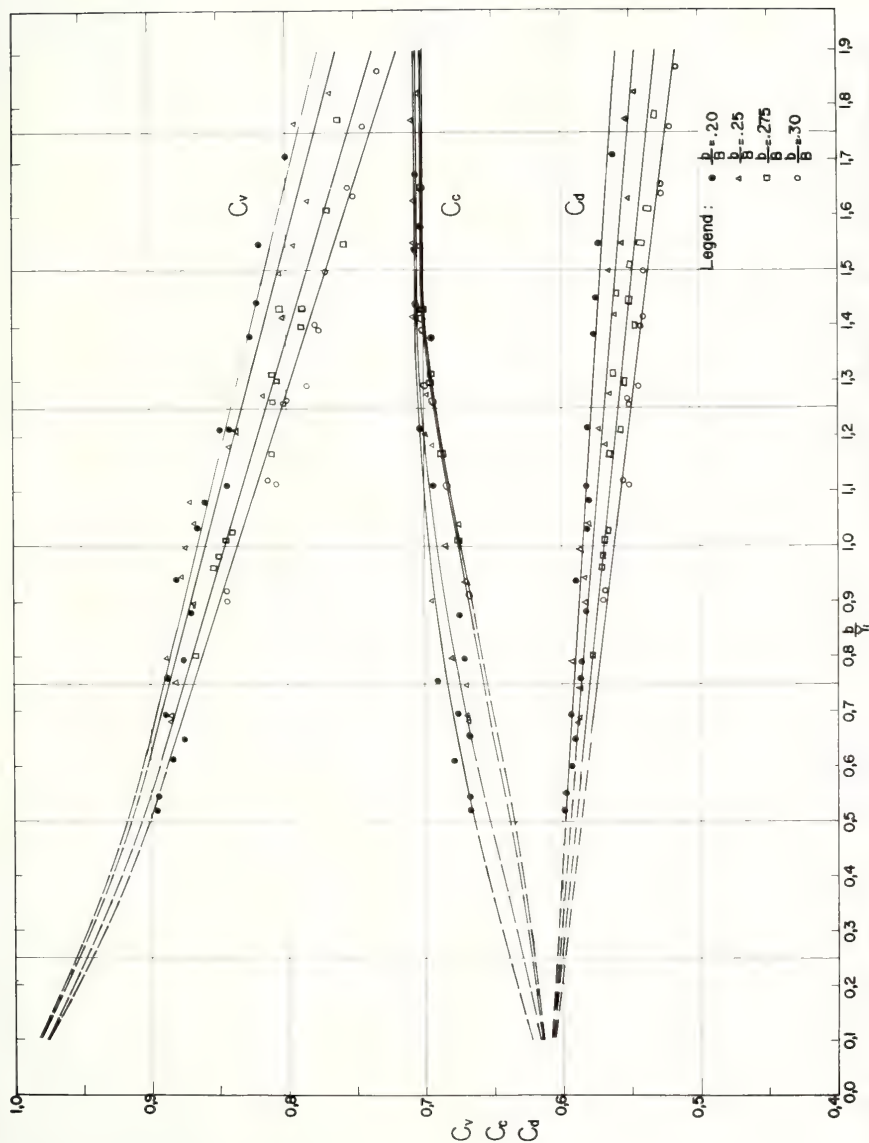


FIG. 8 - 3 - 1 COEFFICIENTS OF VELOCITY, CONTRACTION & DISCHARGE - SUBMERGED INLET BUT UNSUBMERGED DISCHARGE JET.



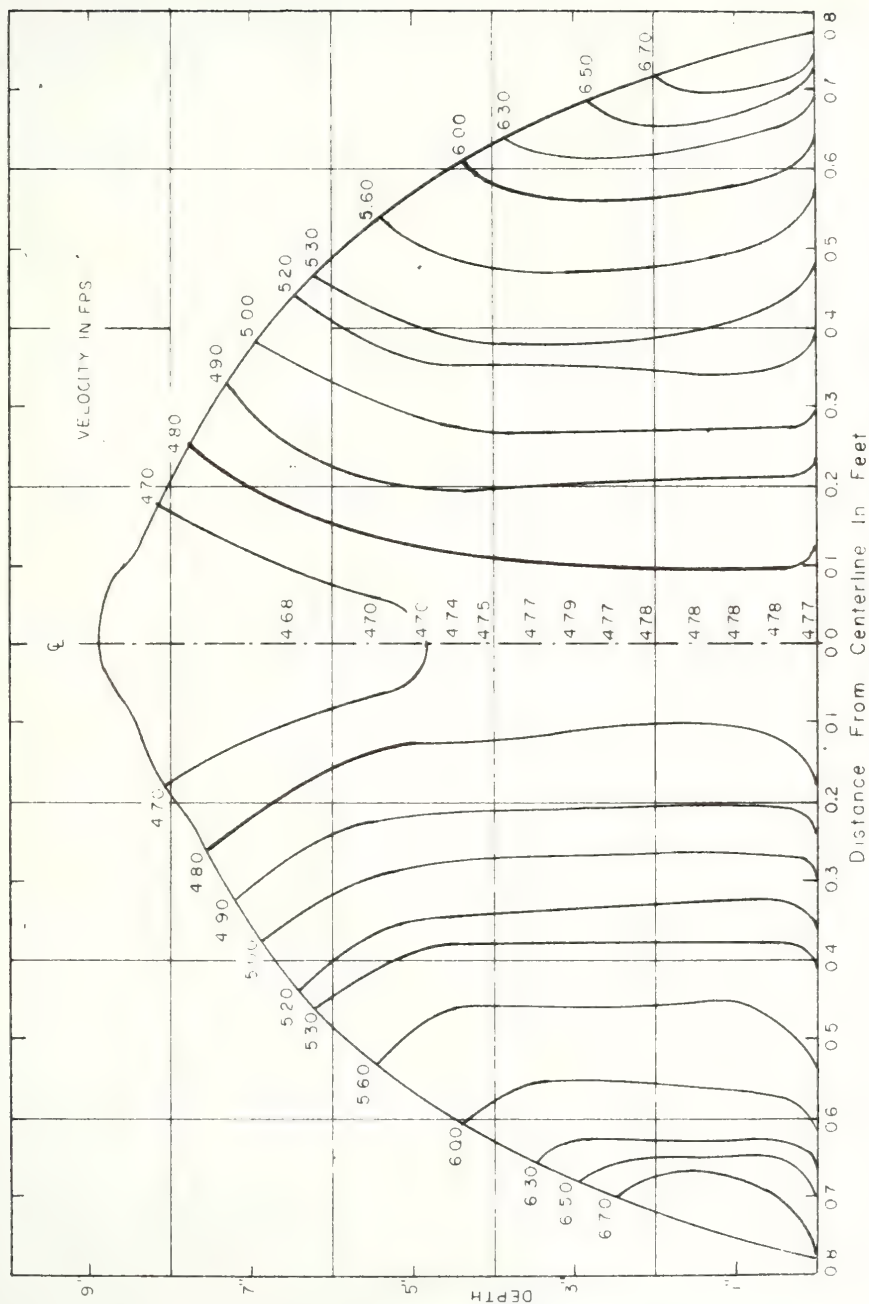


FIG 8-3-2 ISOVELOCITY CURVES AT VENA CONTRACTA



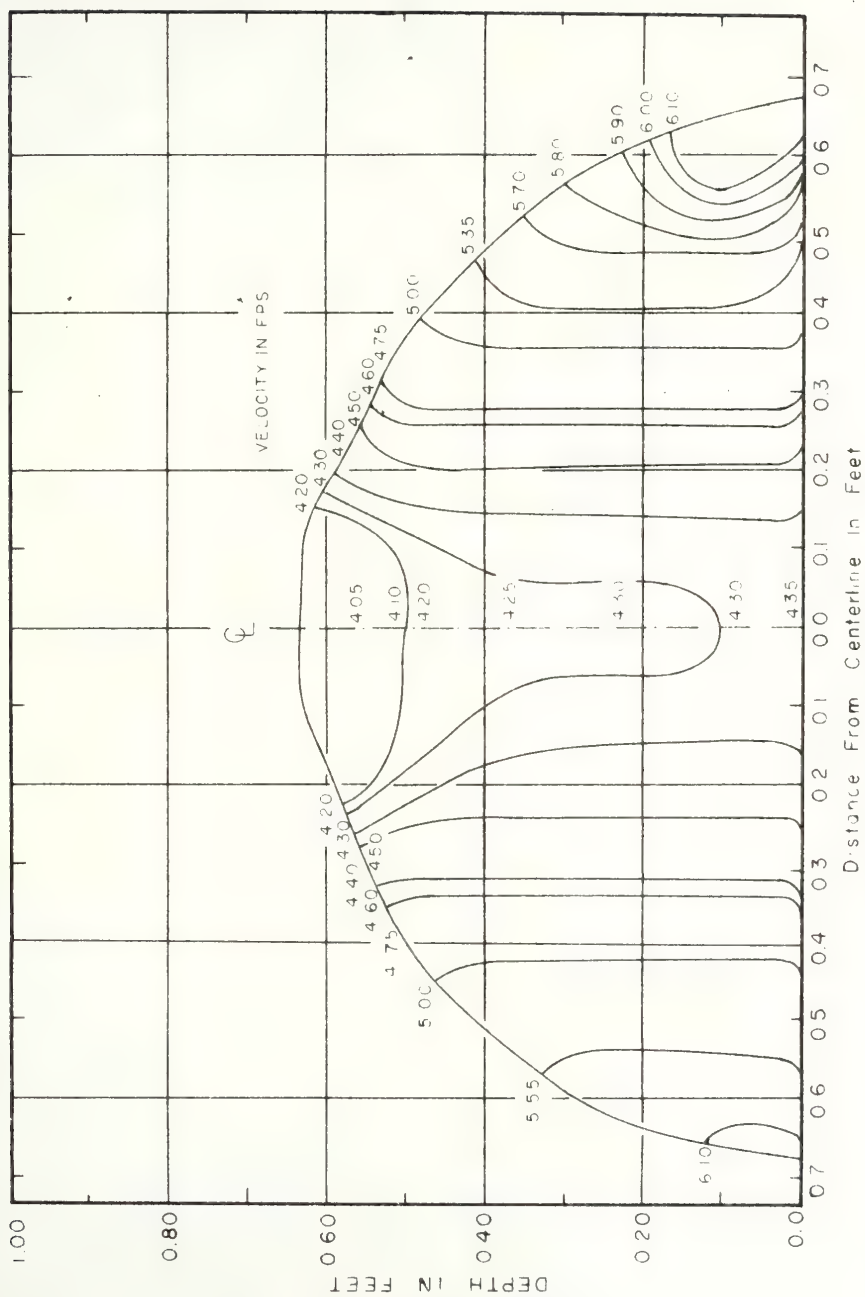


FIG. 8-3-3 ISOVELOCITY CURVES FOR CROSS SECTION AT VENA CONTRACTA



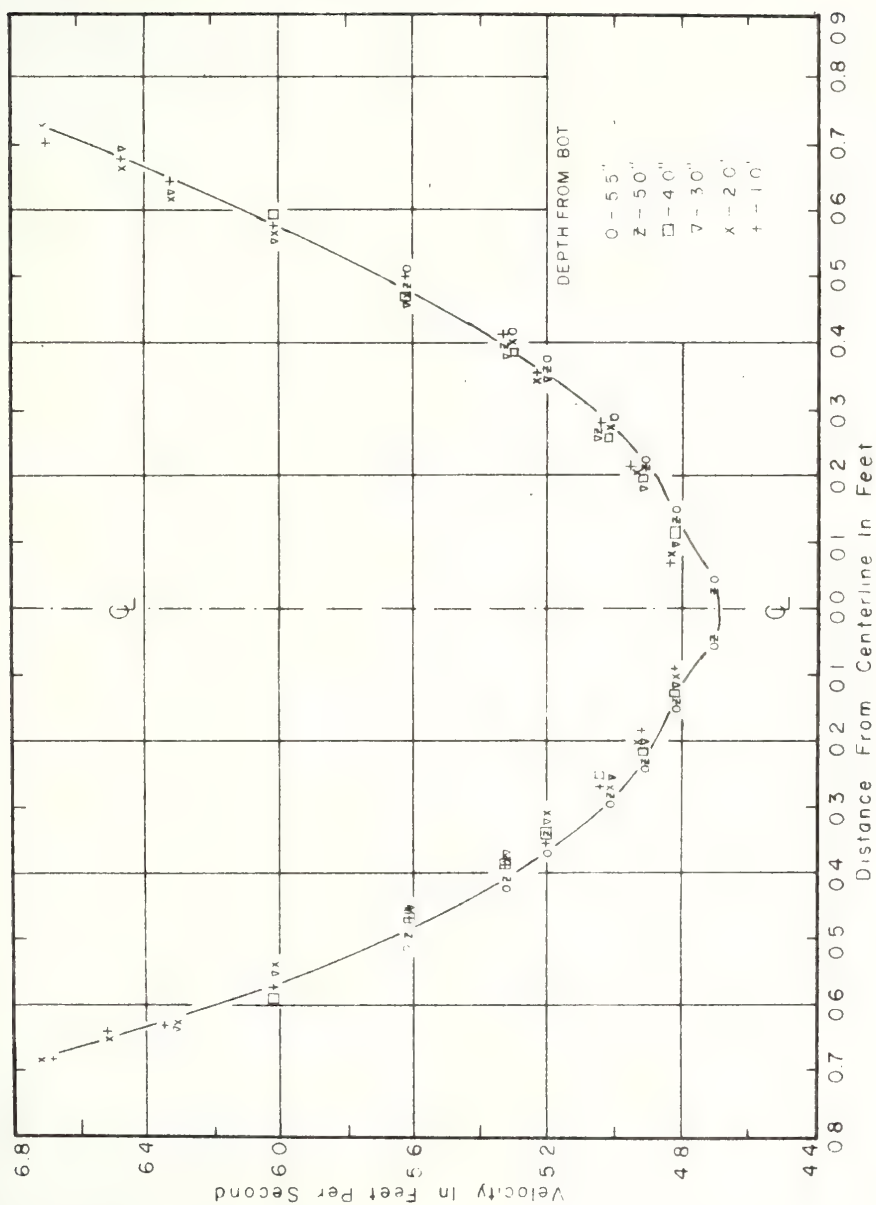


FIG. 8-3-4 VELOCITY DISTRIBUTION AT VENA CONTRACTA





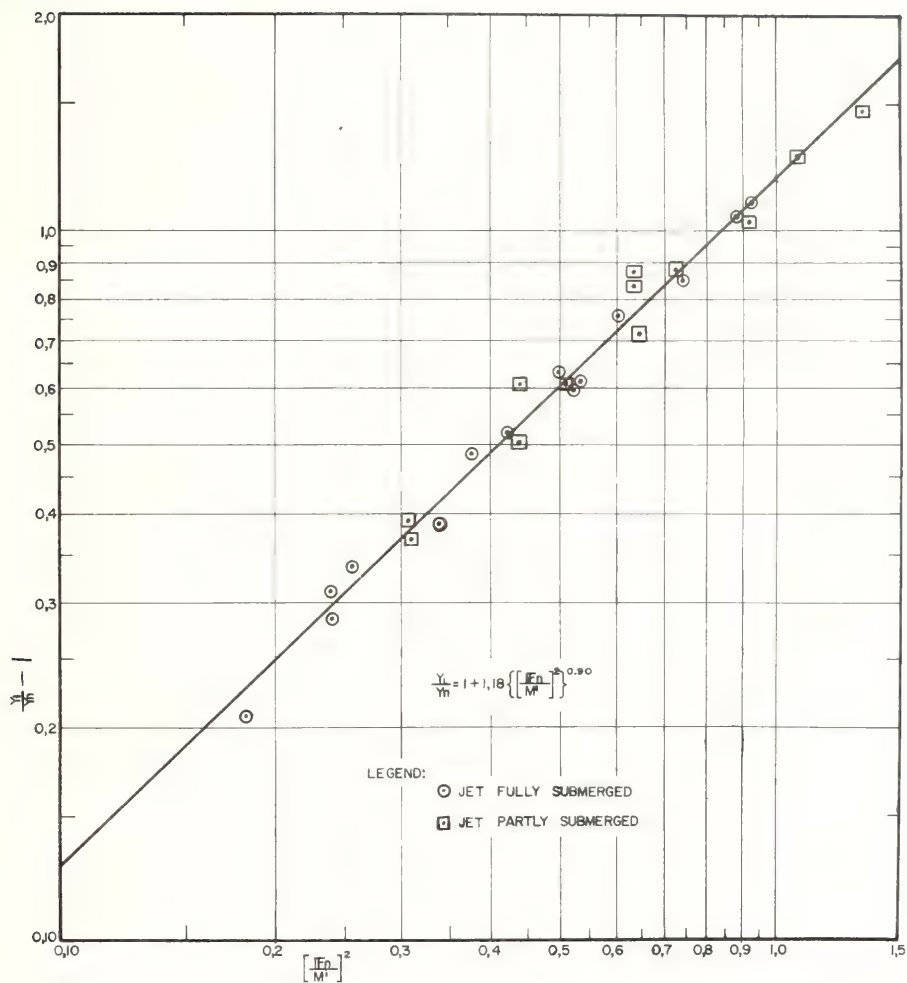


FIG. 8-3-5 GENERALIZED BACKWATER RATIO FOR SUBMERGED INLET. GEOMETRY Ia



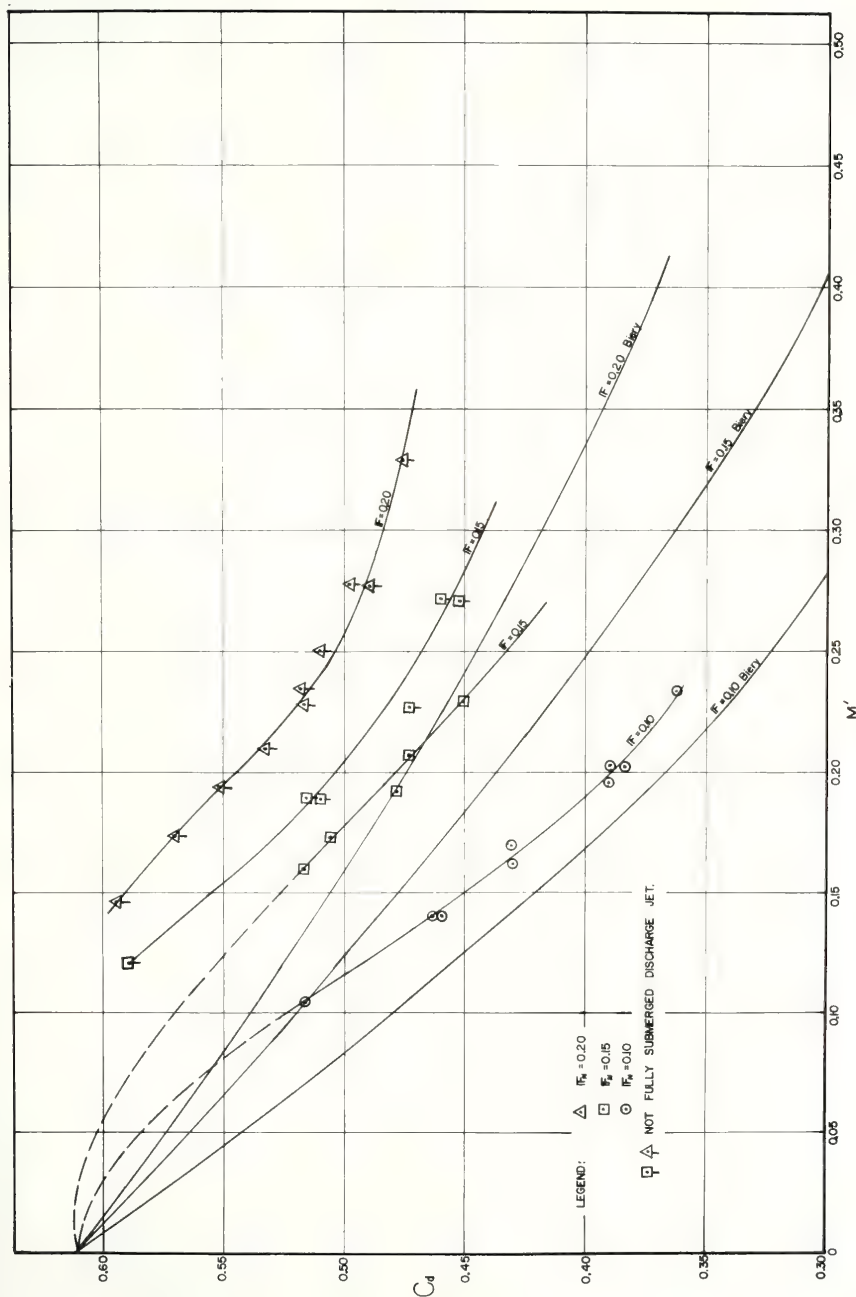
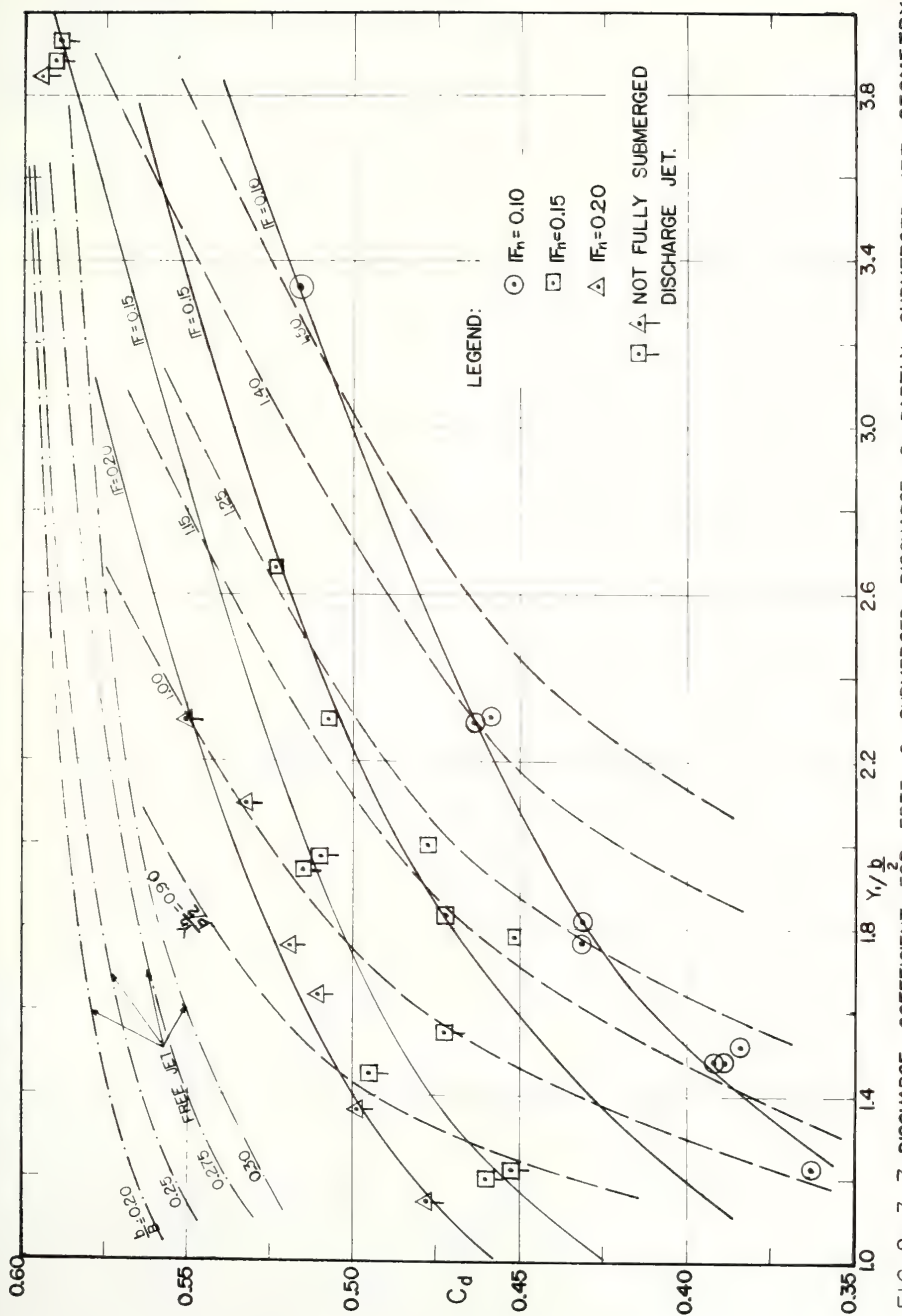


FIG. 8-3-6 DISCHARGE COEFFICIENT VS CHANNEL OPENING RATIO, SMOOTH BOUNDARIES, GEOMETRY I<sub>a</sub>



FIG. 8-3-7 DISCHARGE COEFFICIENT FOR FREE & SUBMERGED DISCHARGE & PARTLY SUBMERGED JET. GEOMETRY I<sub>0</sub>



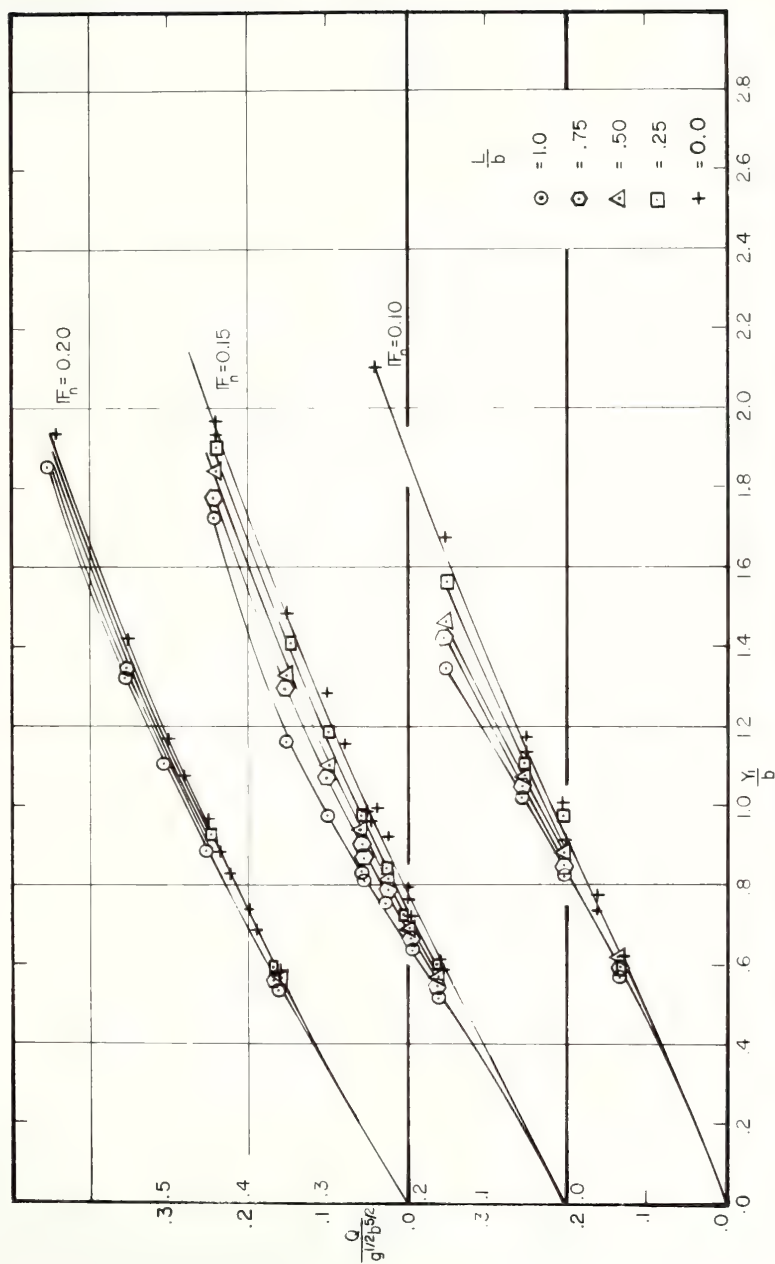


FIG. 8-4-1 DIMENSIONLESS CURVES FOR GEOMETRIES Ia AND Ib. SMOOTH BOUNDARIES





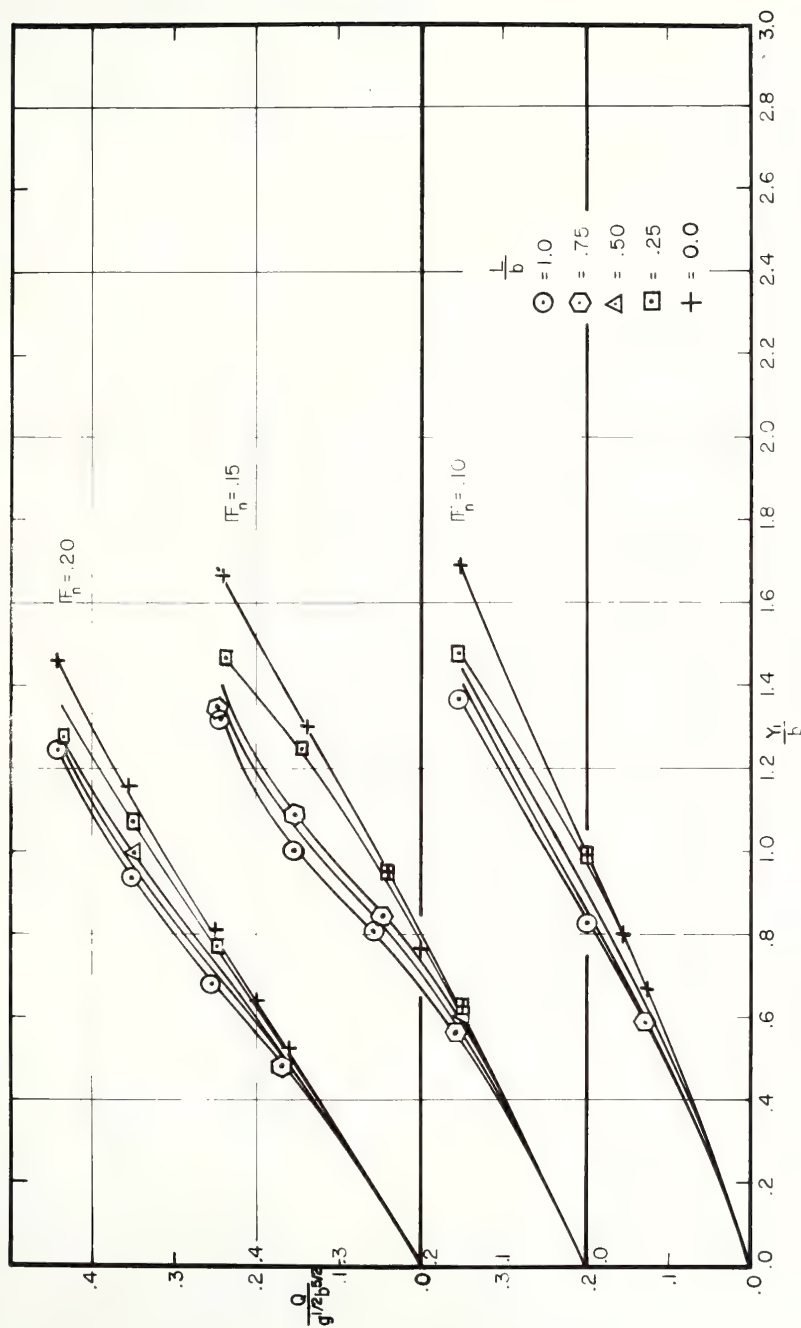


FIG. 8-5-1 DIMENSIONLESS CURVES FOR GEOMETRIES Ia AND Ib. ROUGH BOUNDARIES



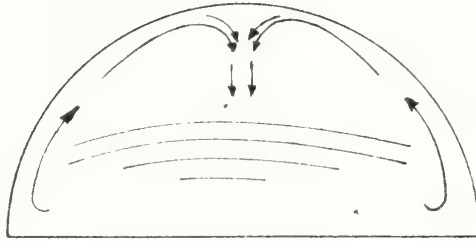


Fig 8-5-2<sub>a</sub> Spiral Motion in Barrel Section Downstream of Vena Contracta

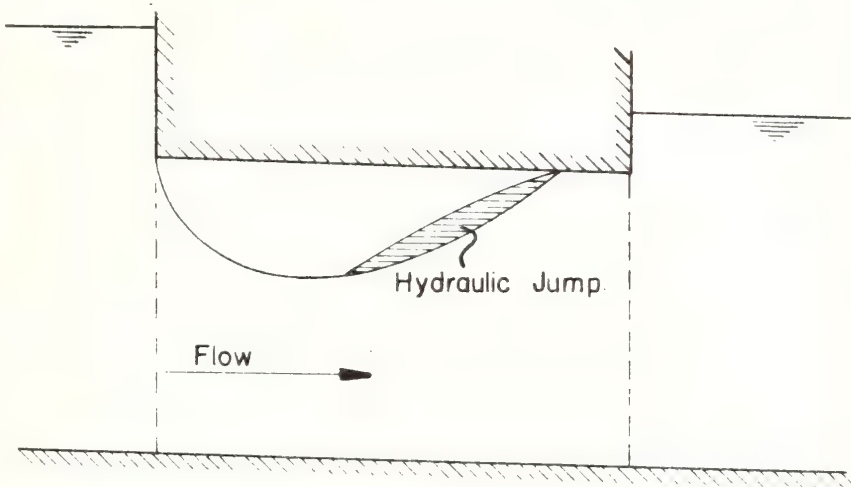


Fig 8-5-2<sub>b</sub> Typical Flow Condition Through Constriction





FIG 8-5-3 SLUG FLOW AT BARREL EXIT



FIG 8-5-4 FREE DISCHARGE JET



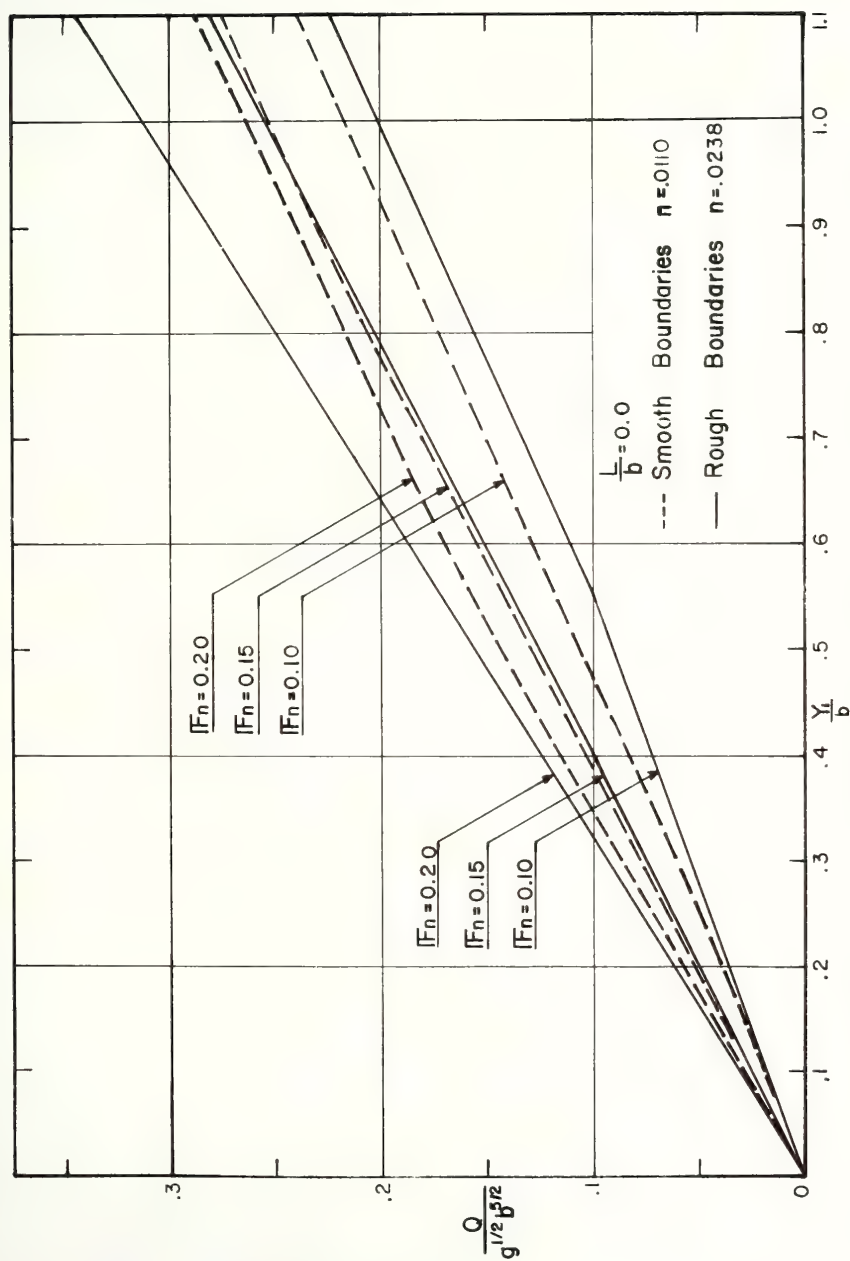


FIG. 8-5-5 Comparison of Dimensionless Curves for Geometry Ia for Smooth and Rough Boundaries





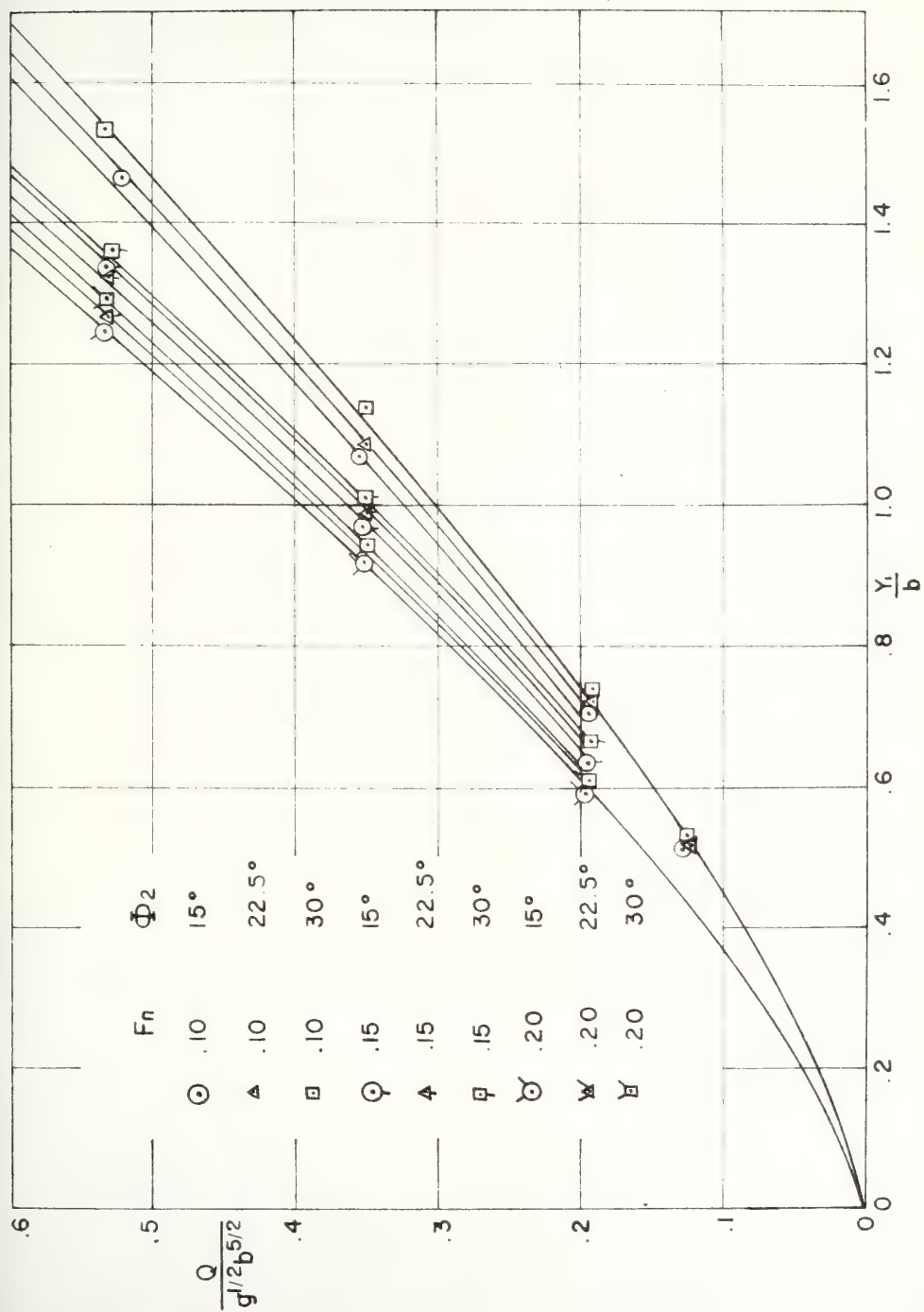


FIG. 8-6-1 Dimensionless Curves for Geometry 2b, Rough Boundaries



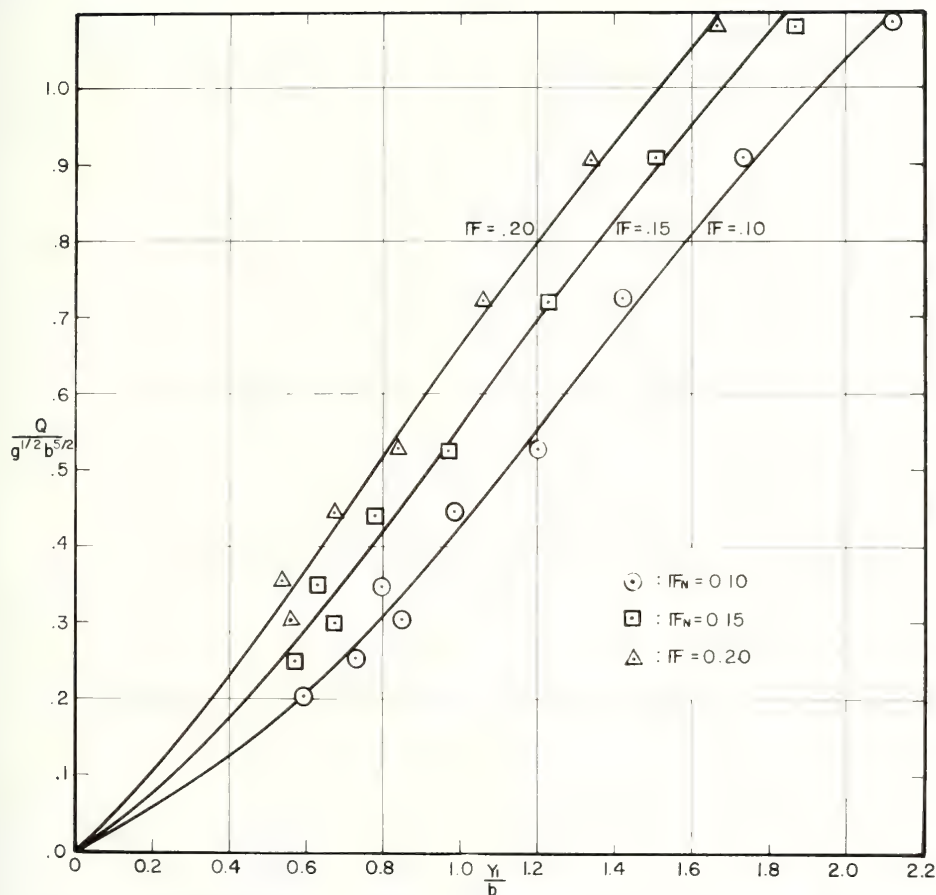


FIG. 8-7-1 DIMENSIONLESS CURVES FOR GEOMETRY VI USING  $IF_n$  AS PARAMETER. ROUGH BOUNDARIES



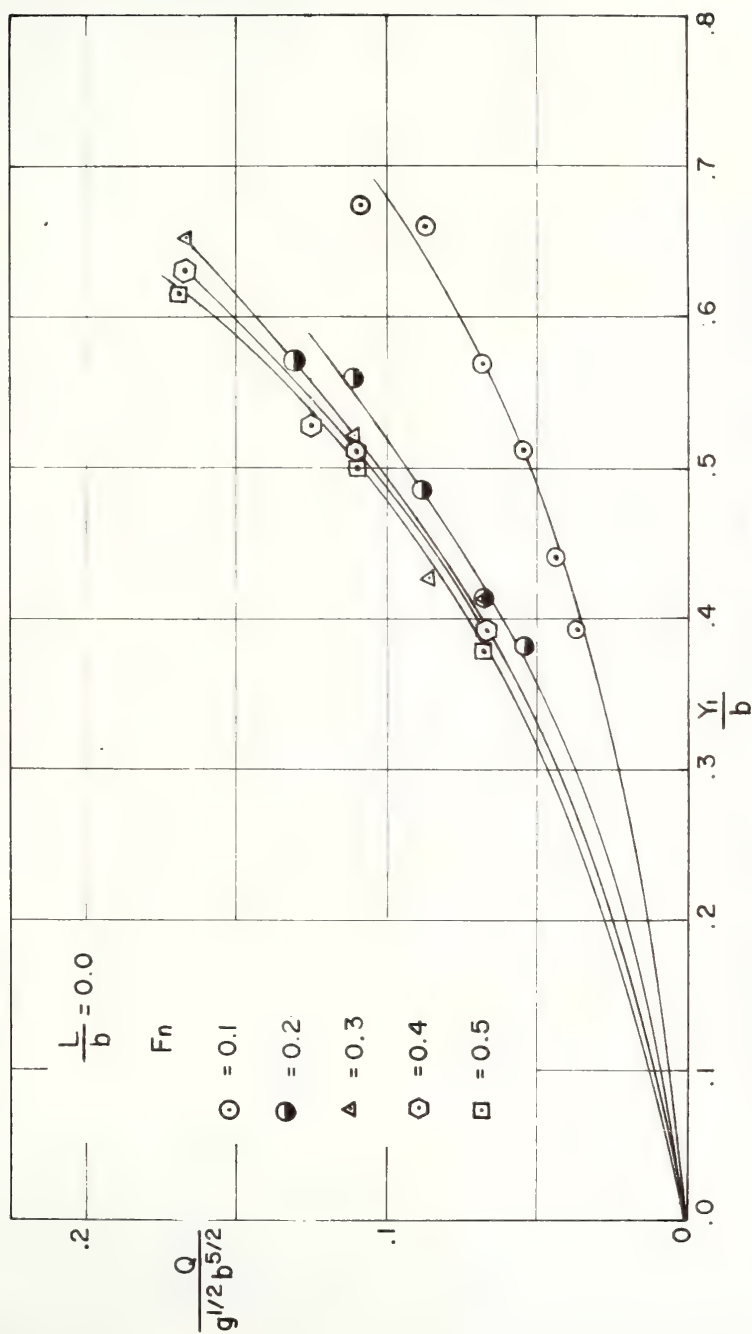


FIG. 8-8-1 Dimensionless Curves for Geometry VII Rough Boundaries



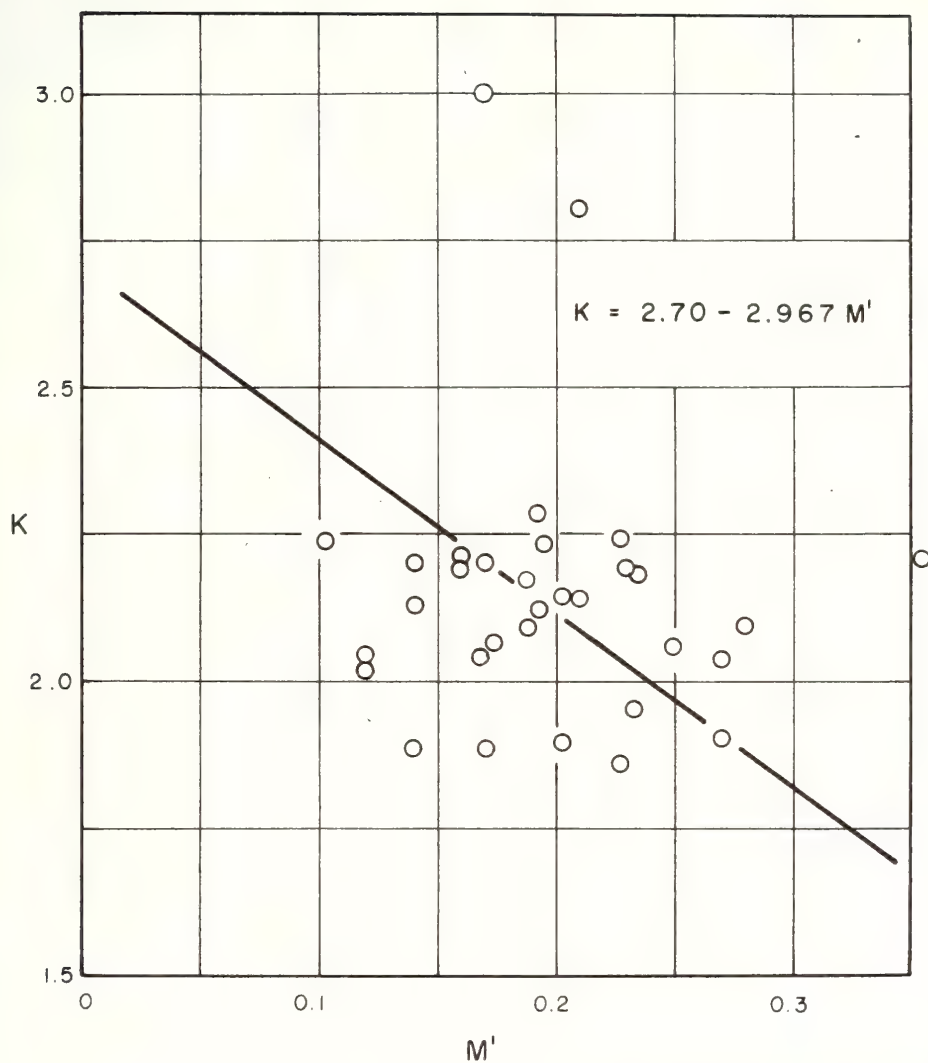


FIG.8-9-1 HEAD LOSS COEFFICIENT FOR GEOMETRY

Ia SMOOTH BOUNDARIES,  $\frac{L}{b} = 0.0$





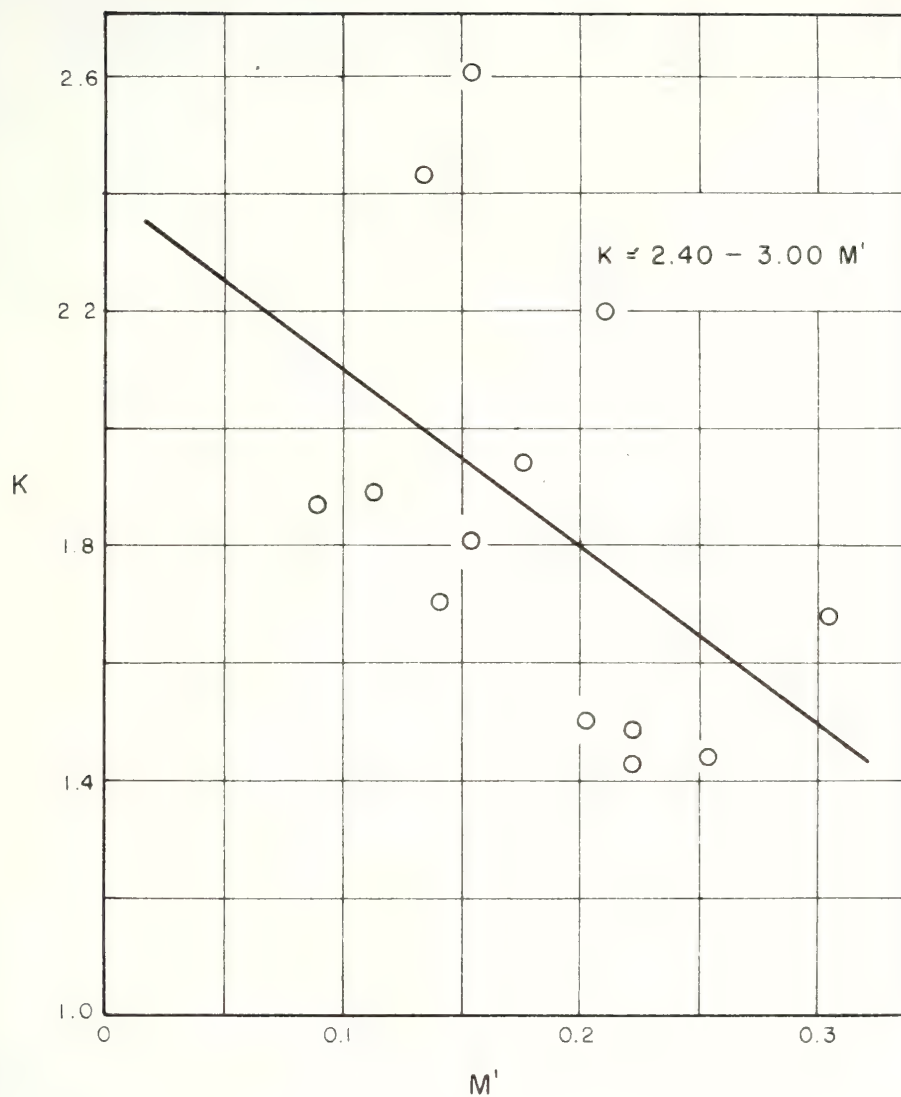


FIG. 8-9-2 HEAD LOSS COEFFICIENT FOR GEOMETRY

I<sub>b</sub> SMOOTH BOUNDARIES,  $\frac{L}{b} = 0.25$



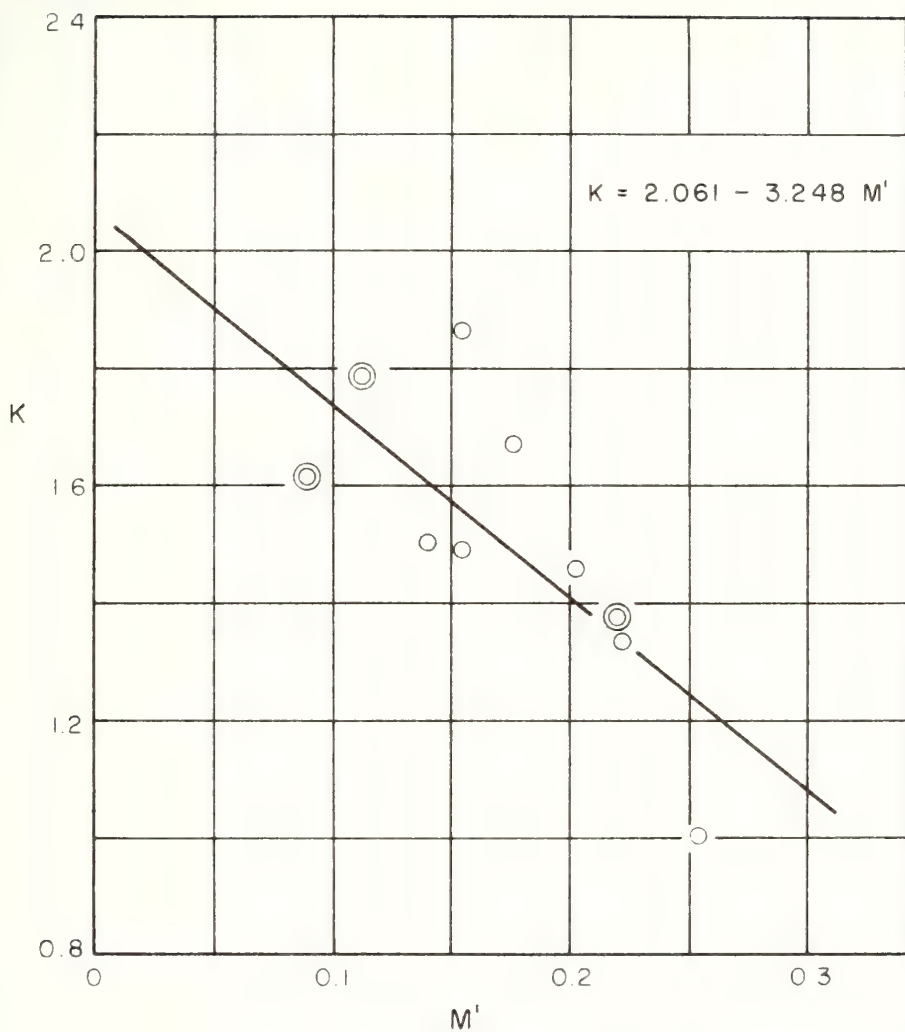


FIG.8-9-3 HEAD LOSS COEFFICIENT FOR GEOMETRY

$I_b$  SMOOTH BOUNDARIES,  $\frac{L}{b} = 0.50$



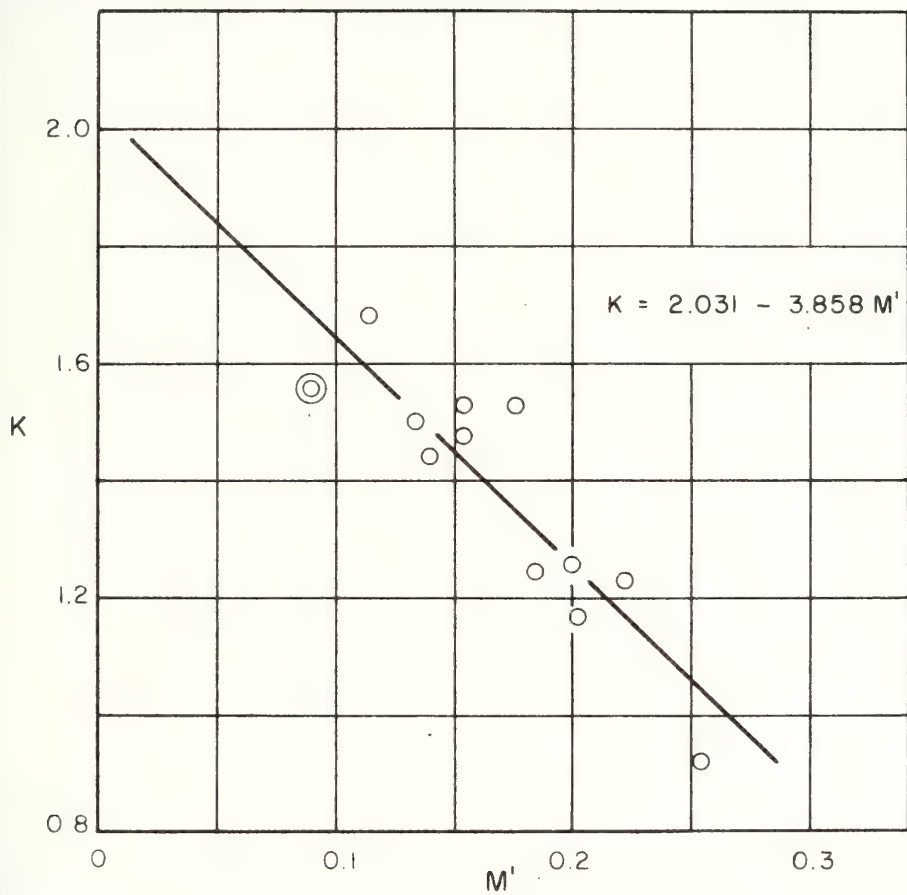


FIG. 8-9-4 HEAD LOSS COEFFICIENT FOR GEOMETRY

$I_b$  SMOOTH BOUNDARIES,  $\frac{L}{b} = 0.75$



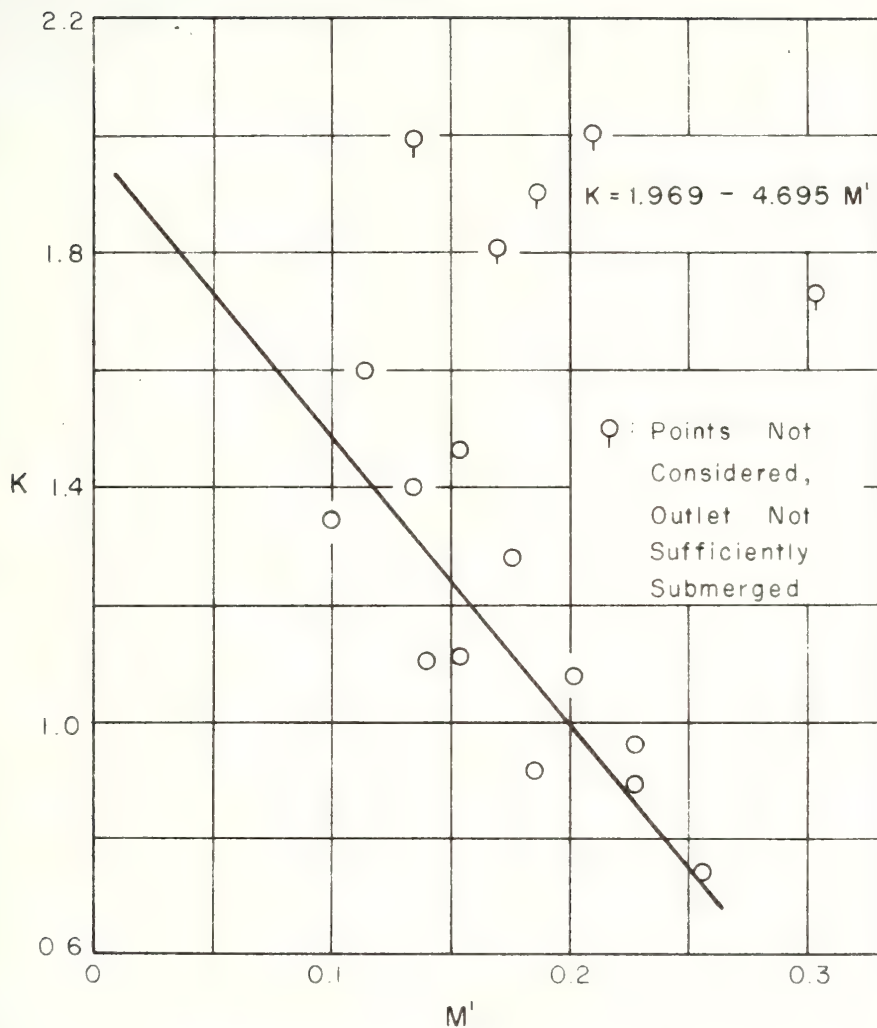


FIG.8-9-5 HEAD LOSS COEFFICIENT FOR GEOMETRY

 $I_b$ , SMOOTH BOUNDARIES,  $\frac{L}{b} = 1.00$





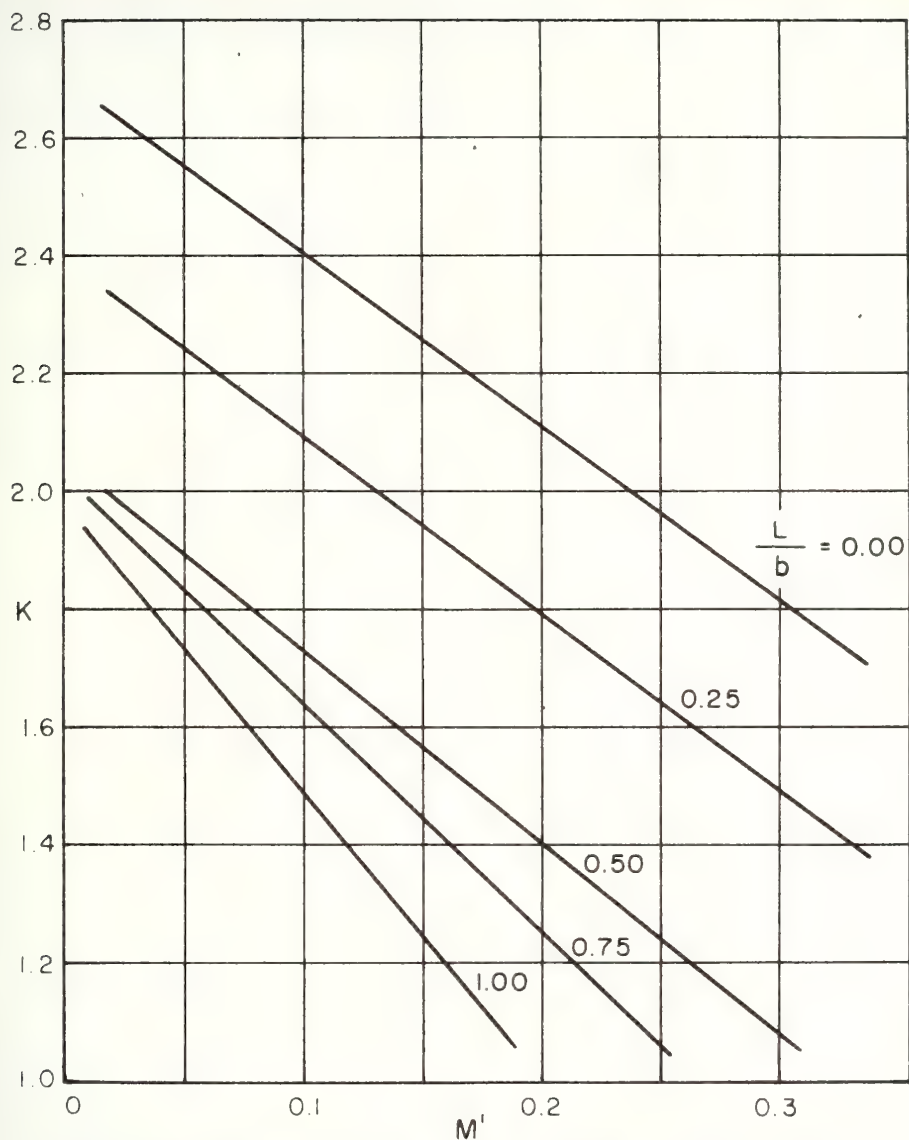


FIG.8-9-6 SUMMARY OF HEAD LOSS COEFFICIENT  
CURVES FOR GEOMETRIES  $I_a$ , &  $I_b$ ,  
SMOOTH BOUNDARIES



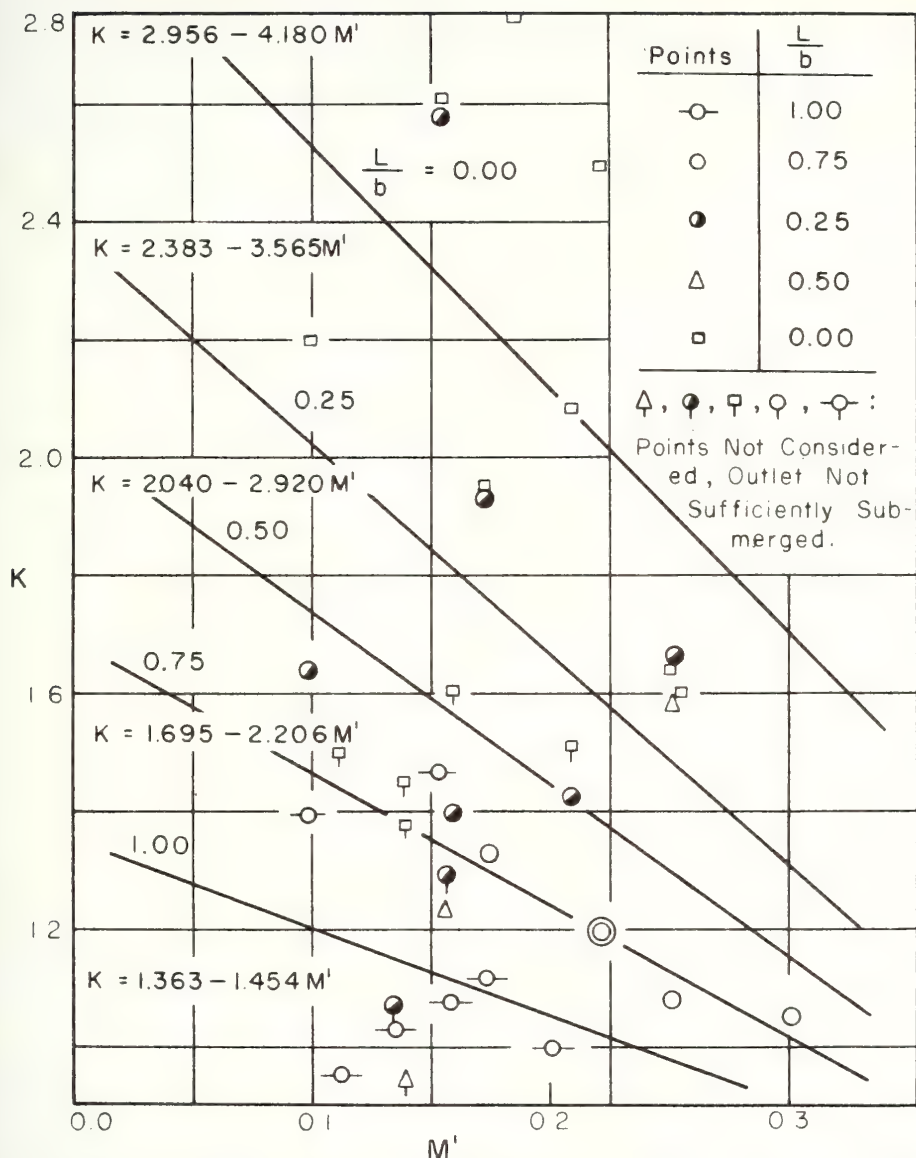


FIG.8-9-7 HEAD LOSS COEFFICIENT CURVES FOR GEOMETRIES  $I_0$ , &  $I_b$ , ROUGH BOUNDARIES



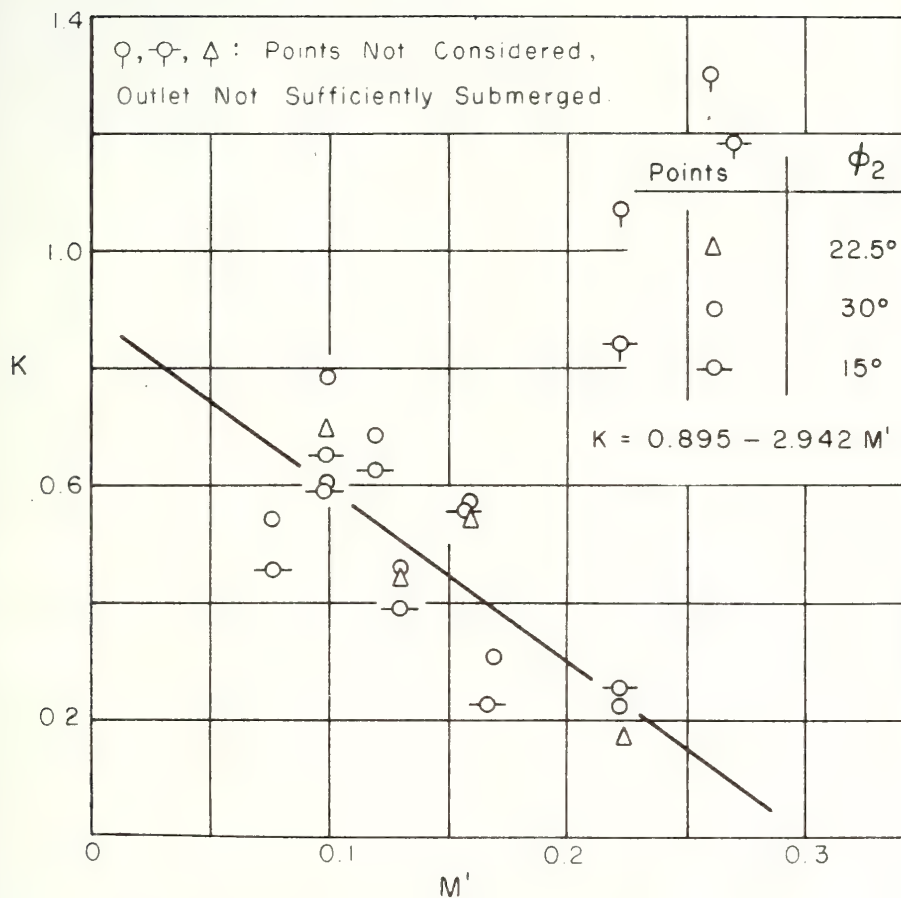


FIG 8-9-8 HEAD LOSS COEFFICIENT CURVE FOR  
GEOMETRY  $V_b$ , ROUGH BOUNDARIES



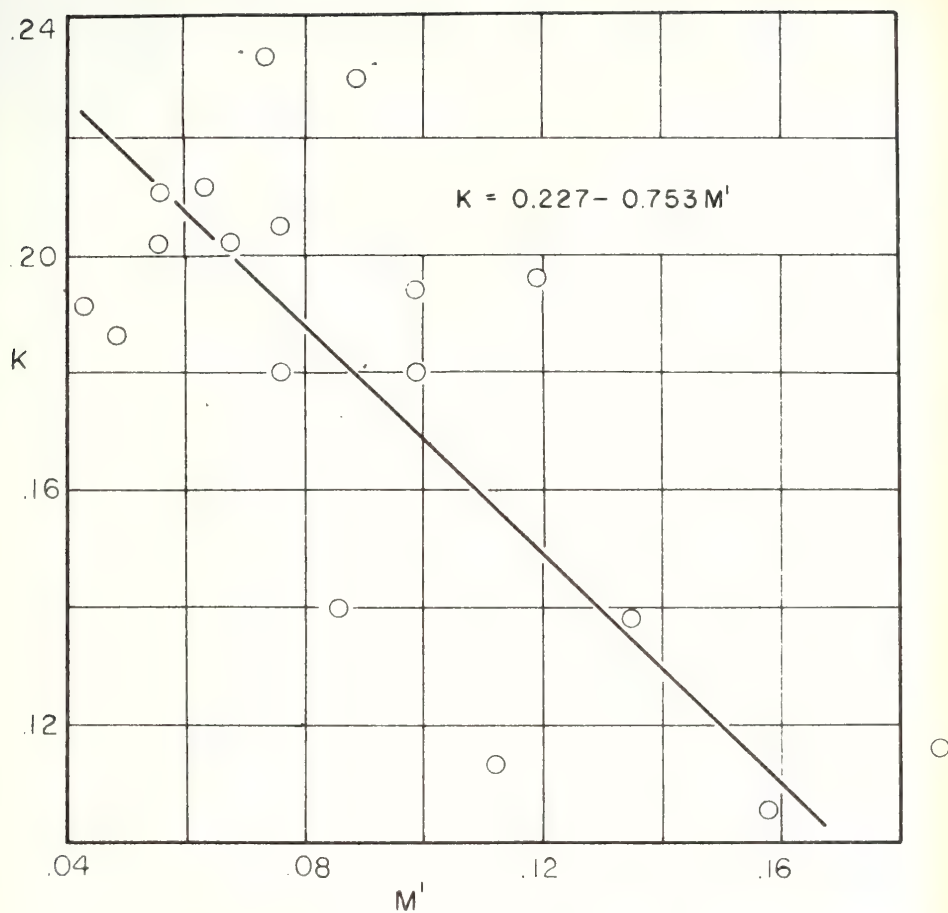


FIG.8-9-9 HEAD LOSS COEFFICIENT CURVE FOR GEOMETRY VI, ROUGH BOUNDARIES





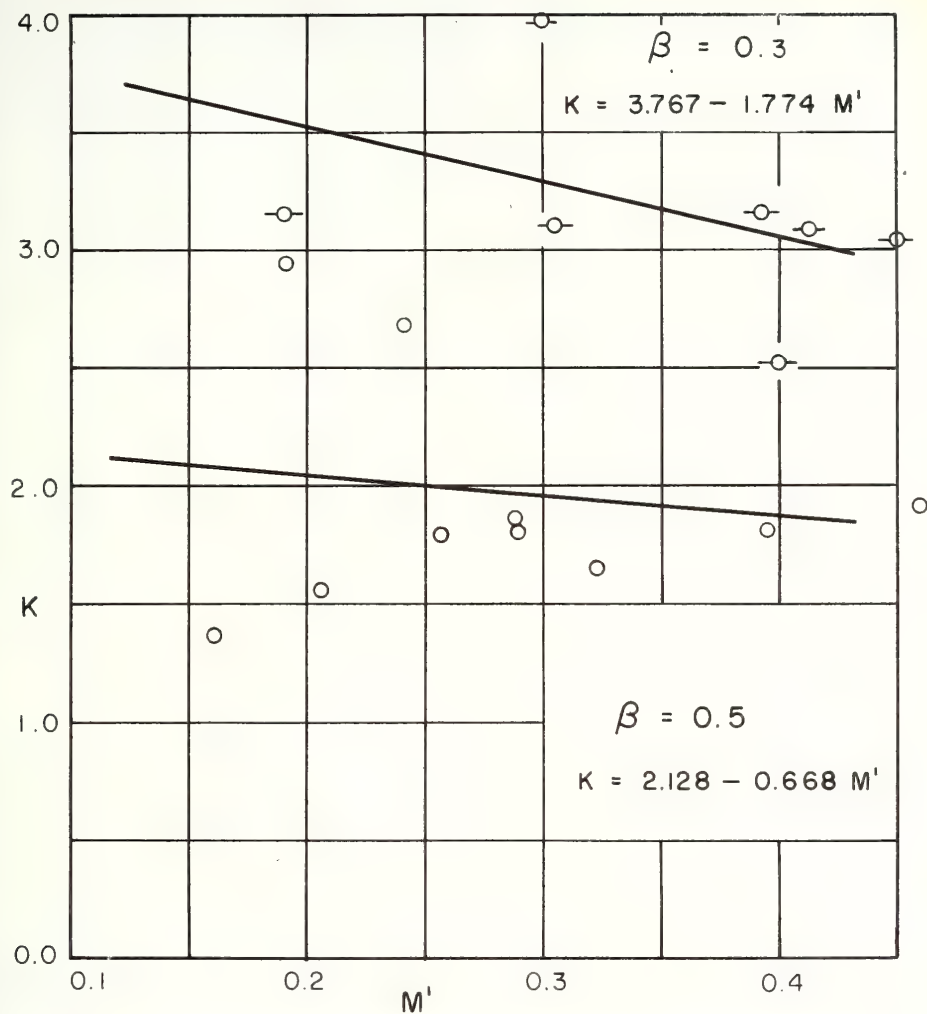


FIG. 8-9-10 HEAD LOSS COEFFICIENT CURVES FOR  
GEOMETRY VII, ROUGH BOUNDARIES



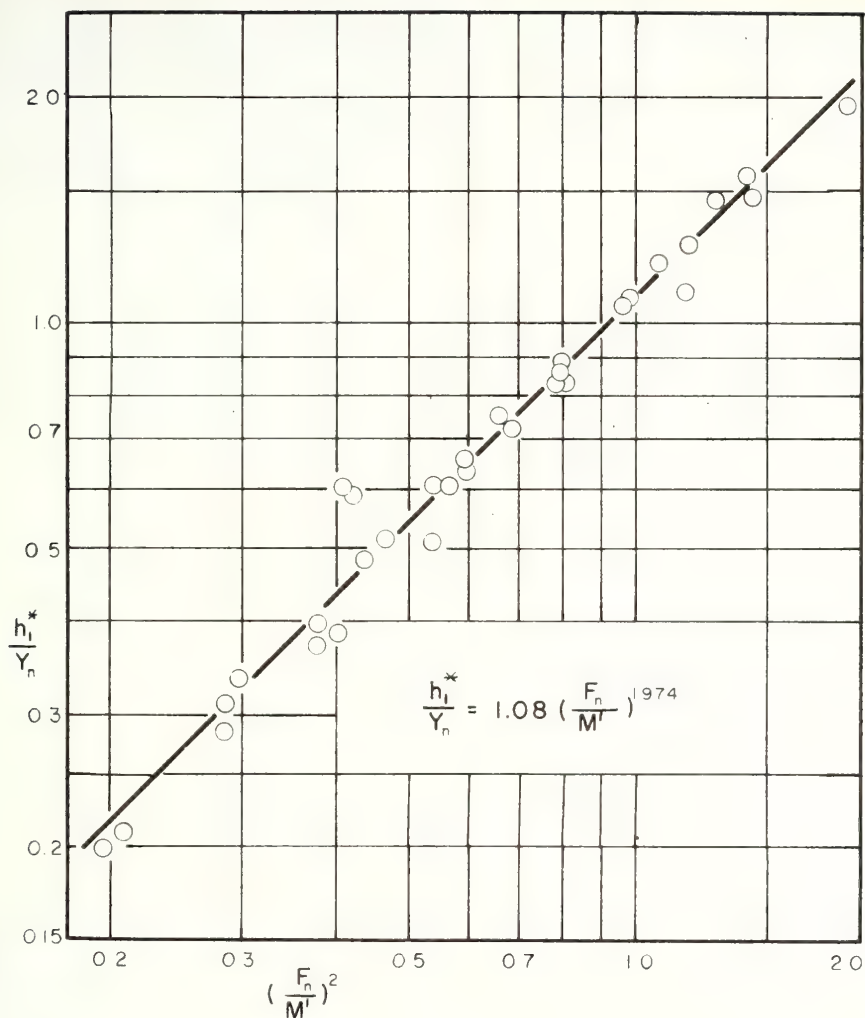


FIG.8-10-IGENERALIZED BACKWATER RATIO GEOMETRY

Ia , SMOOTH BOUNDARIES ,  $\frac{L}{b} = 0.0$



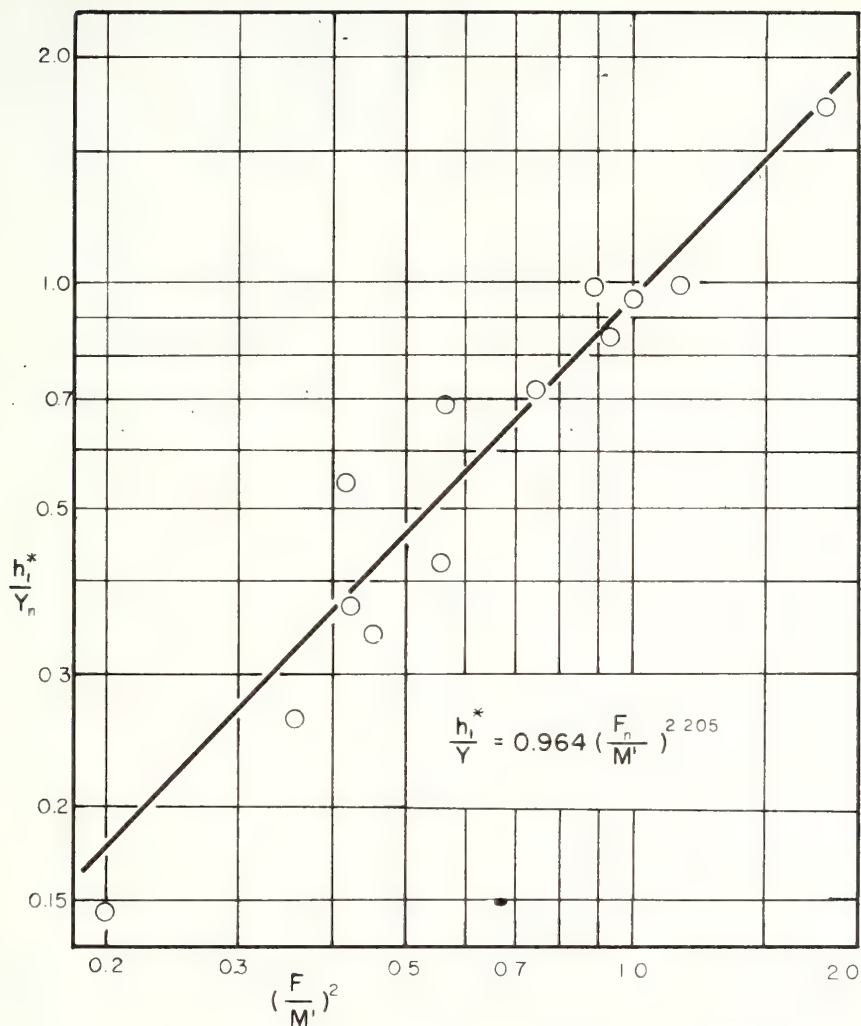


FIG.8-10-2GENERALIZED BACKWATER RATIO GEOMETRY  
Ib, SMOOTH BOUNDARIES,  $\frac{L}{b} = 0.25$



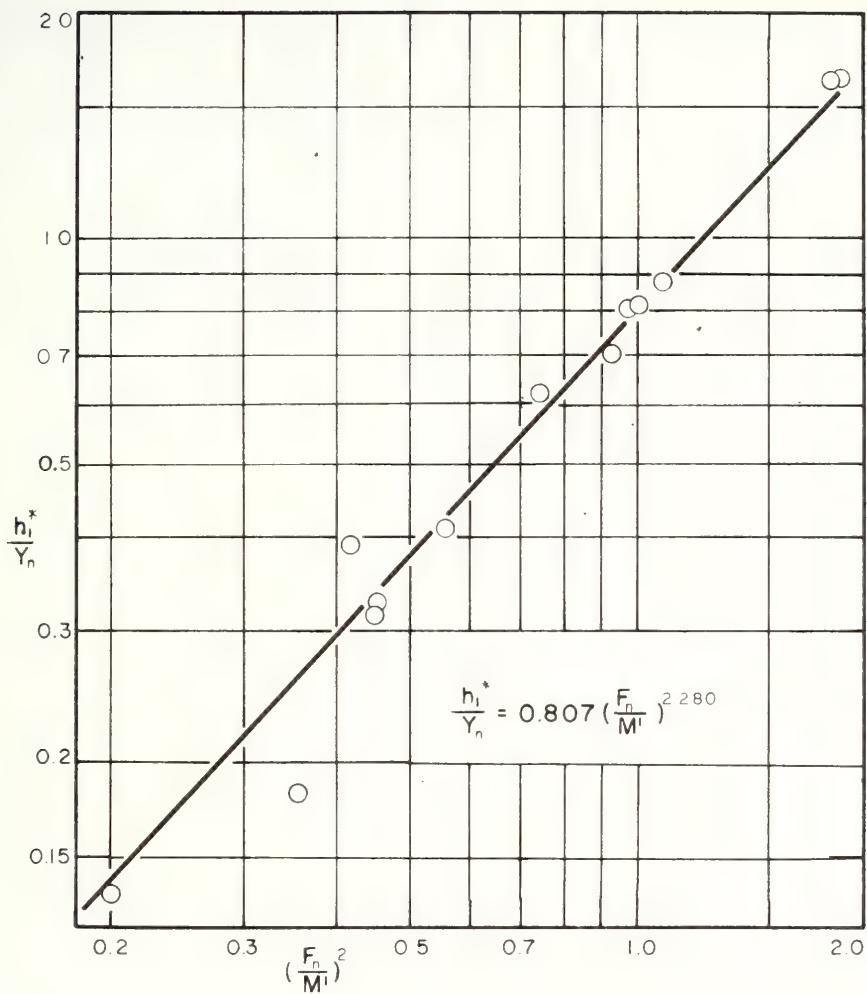


FIG. 8-10-3 GENERALIZED BACKWATER RATIO GEOMETRY

Ib, SMOOTH BOUNDARIES,  $\frac{L}{b} = 0.50$





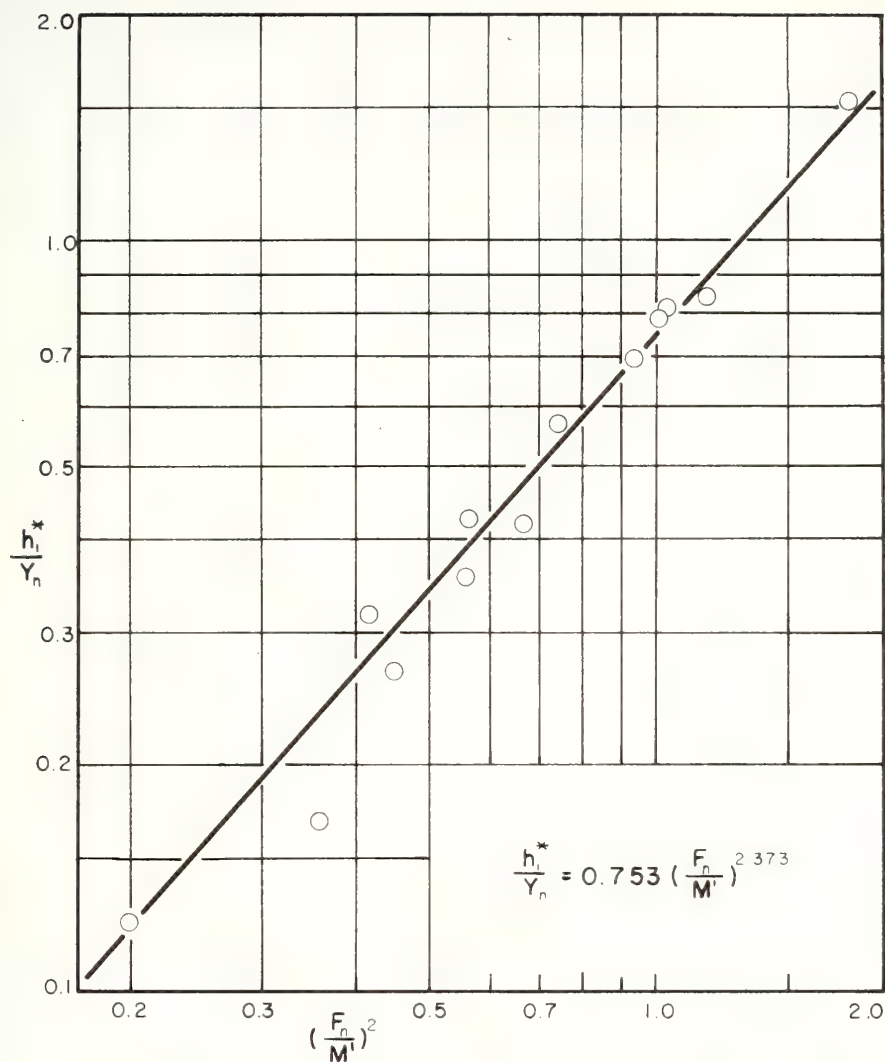


FIG. 8-10-4 GENERALIZED BACKWATER RATIO GEOMETRY  
Ib, SMOOTH BOUNDARIES,  $\frac{L}{b} = 0.75$



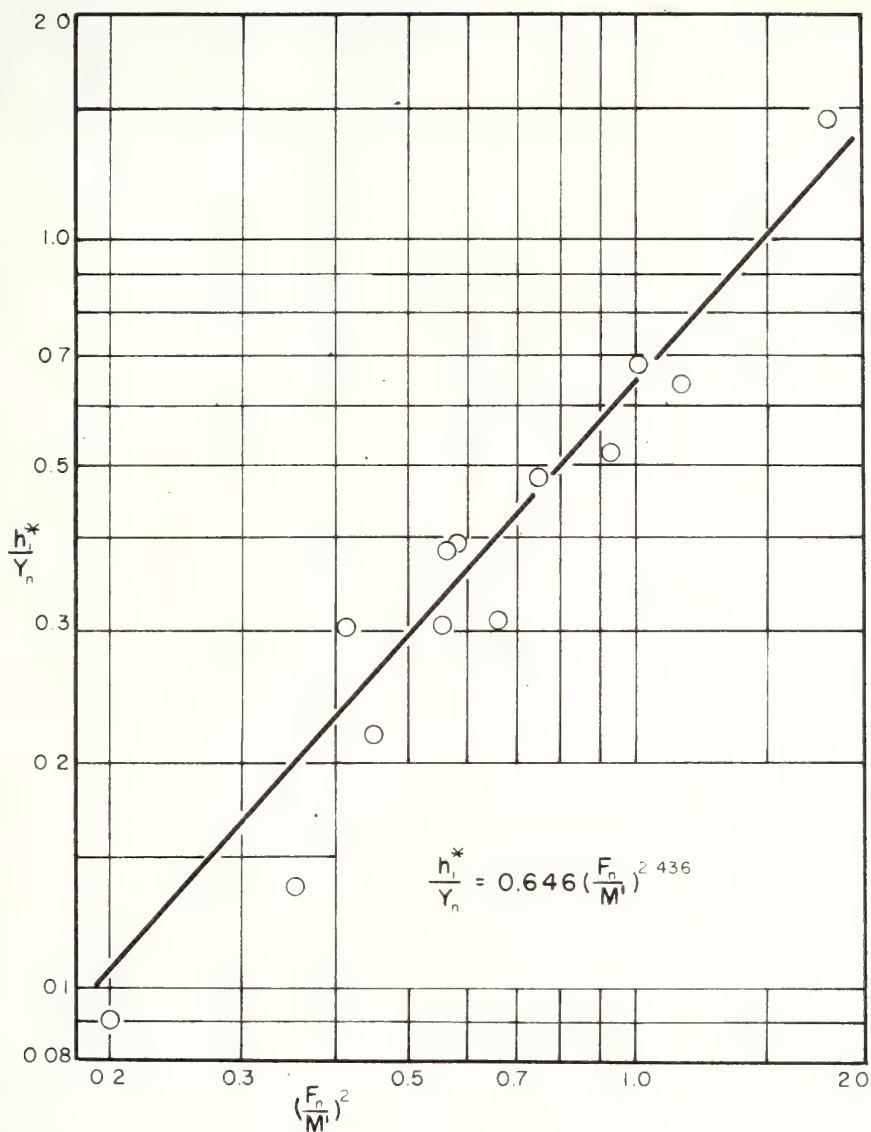


FIG. 8-10-5 GENERALIZED BACKWATER RATIO GEOMETRY  
 1b, SMOOTH BOUNDARIES,  $\frac{L}{b} = 1.0$



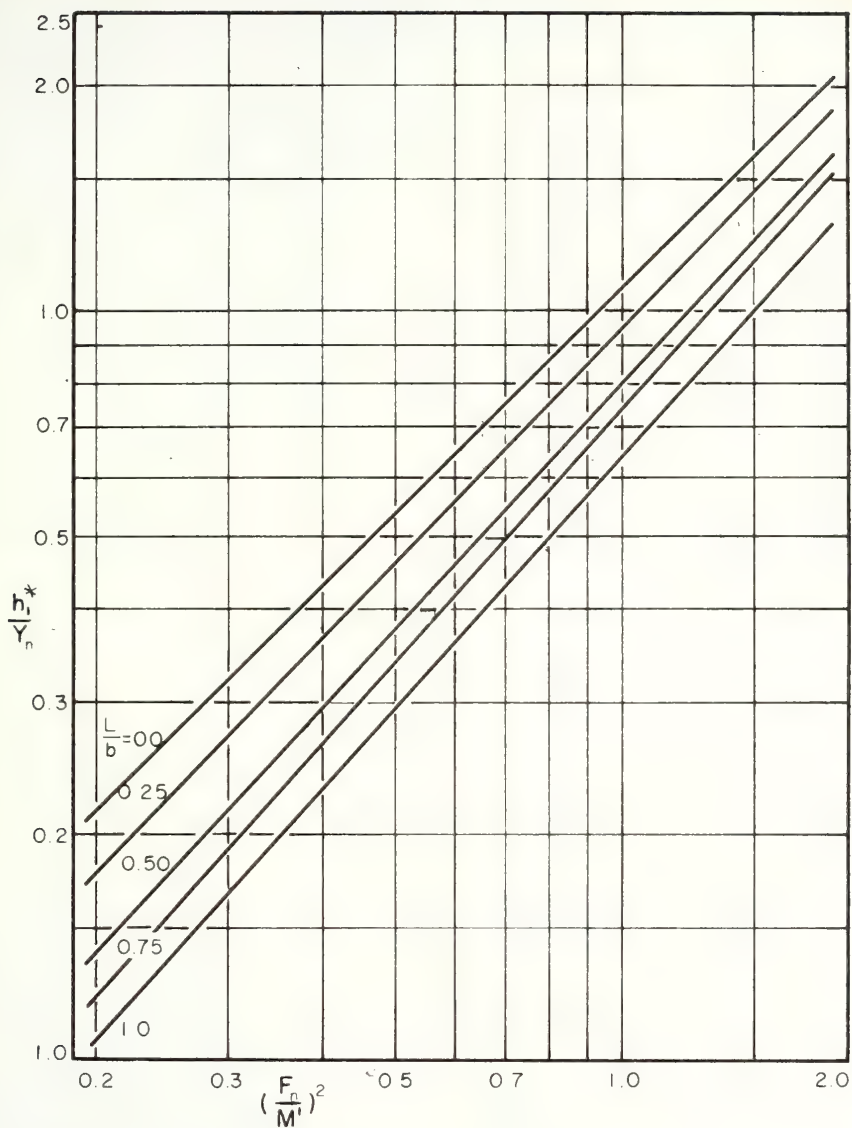


FIG. 8-10-6 SUMMARY OF BACKWATER RATIO CURVES FOR GEOMETRIES Ia AND Ib , SMOOTH BOUNDARIES



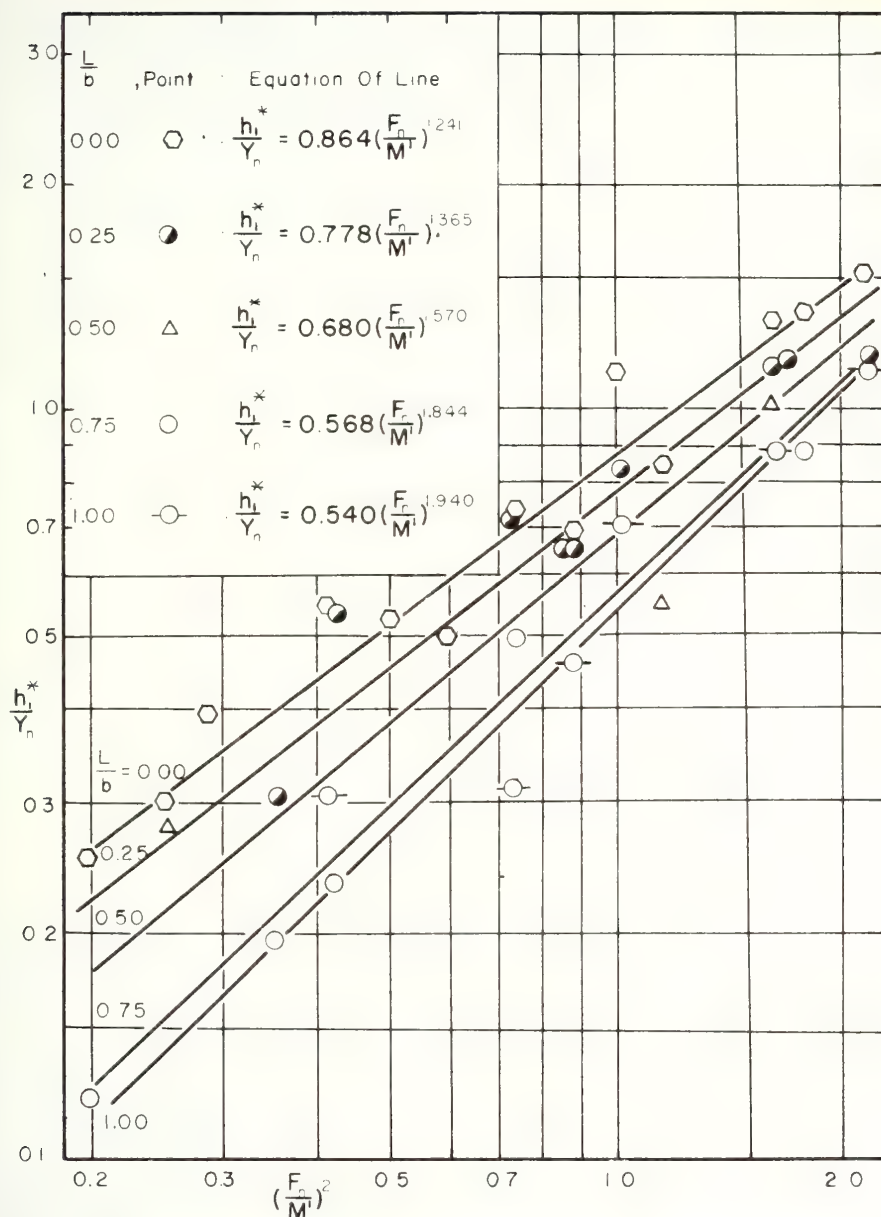


FIG. 8-10-7 GENERALIZED BACKWATER RATIO GEOMETRIES  
 Ia AND Ib, ROUGH BOUNDARIES





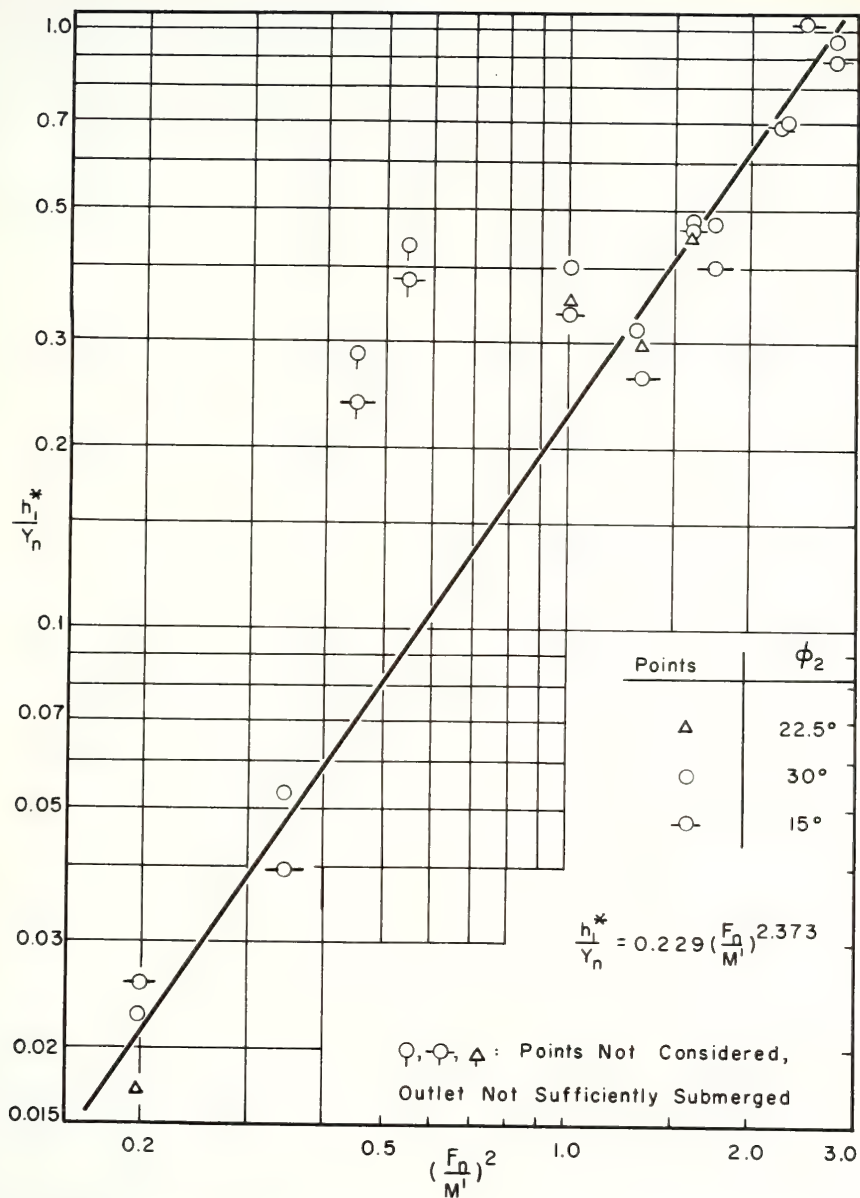


FIG. 8-10-8 GENERALIZED BACKWATER RATIO GEOMETRY  $\nabla b$ ,  
 ROUGH BOUNDARIES



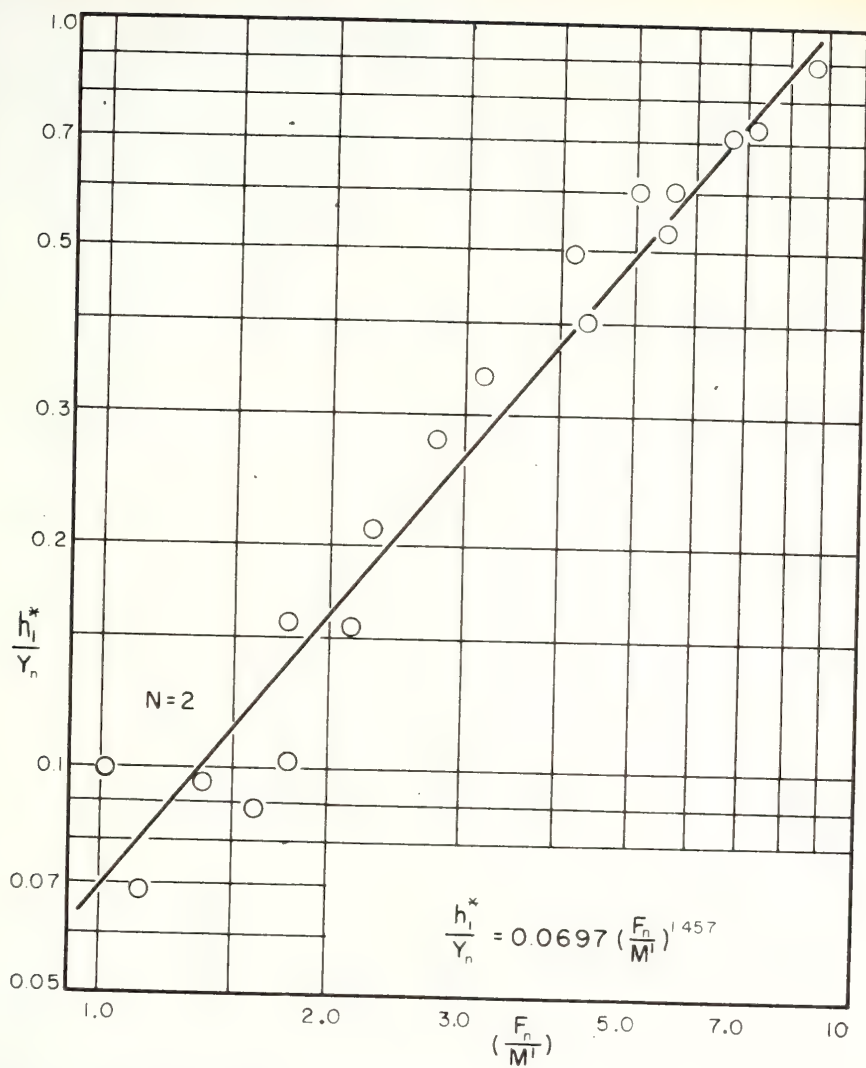


FIG. 8-10-9 GENERALIZED BACKWATER RATIO GEOMETRY  
VI, ROUGH BOUNDARIES



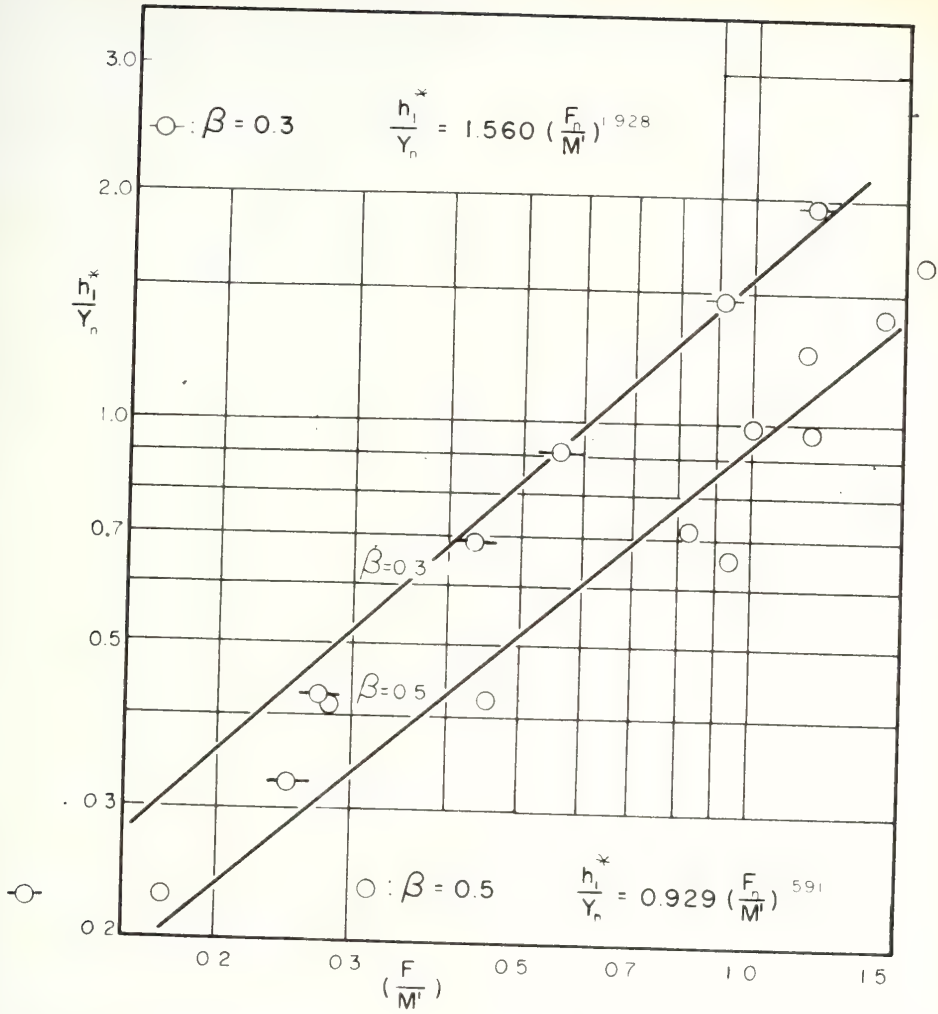
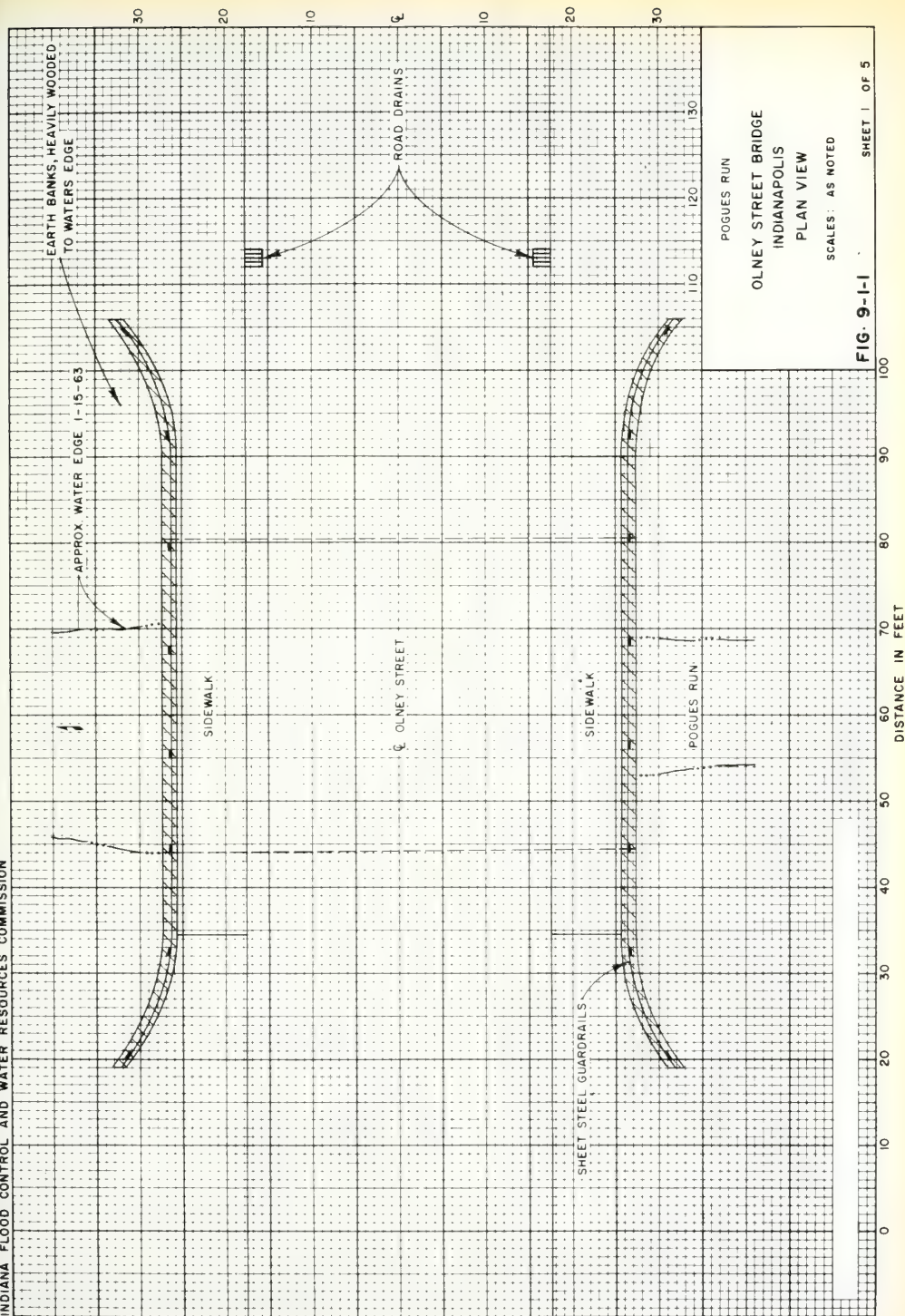


FIG. 8-10-10 GENERALIZED BACKWATER RATIO GEOMETRY  
VII, ROUGH BOUNDARIES









CROWN OF ROAD

METAL HANDRAIL

CONCRETE BRIDGE

GROUND

W S 1-15-63

POGUES RUN

OLNEY STREET BRIDGE  
INDIANAPOLIS  
UPSTREAM FACE

SCALES: AS NOTED

FIG. 9-1-2

SHEET 2 OF 5

NOTE: ALL SECTIONS ARE PLOTTED LOOKING IN DOWNSTREAM DIRECTION

DISTANCE IN FEET

100

90

80

70

60

50

40

30

20

10

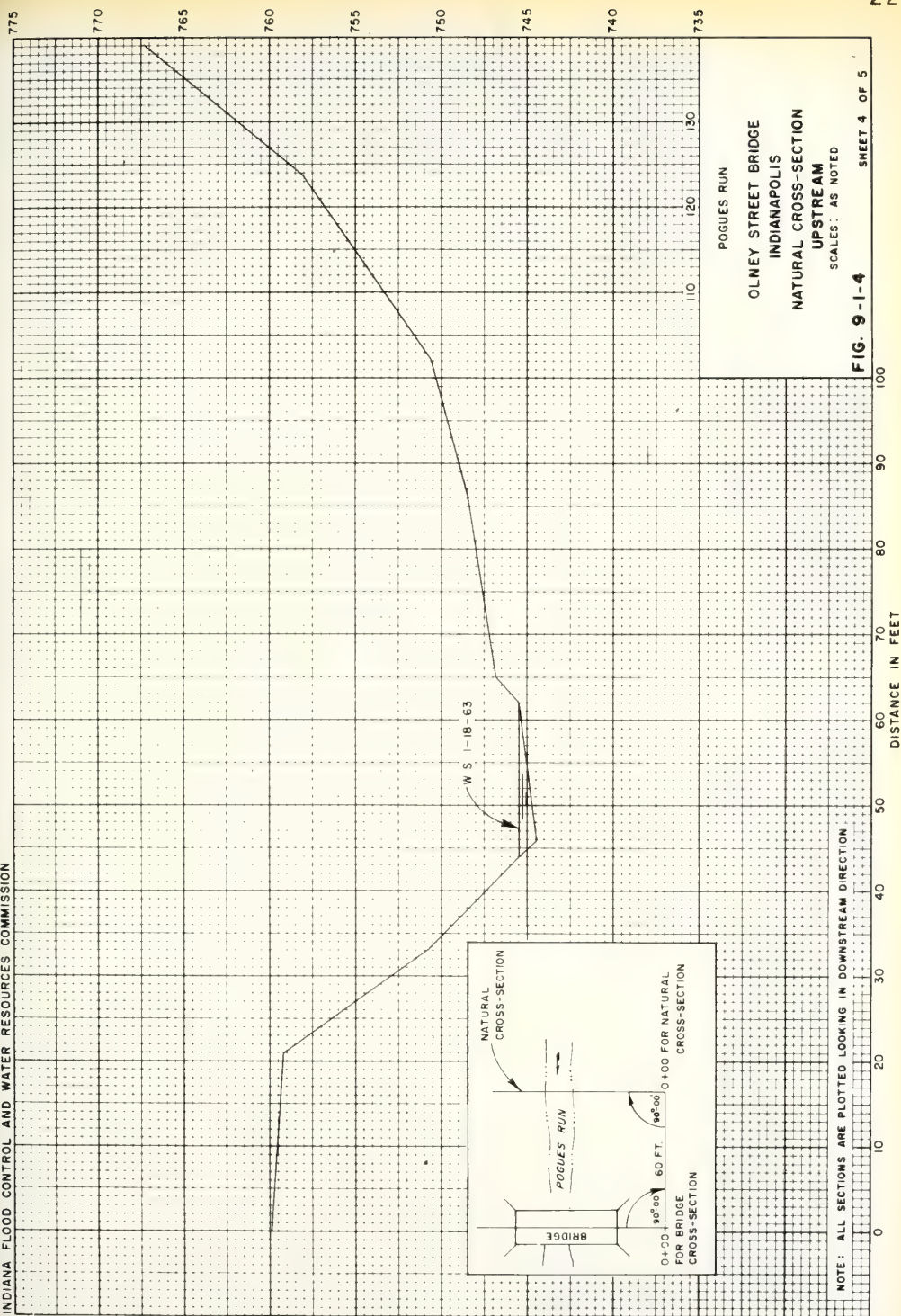
0

110 120 130



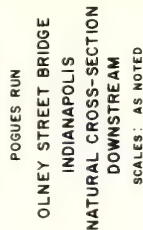












NOTE: ALL SECTIONS ARE PLOTTED LOOKING IN DOWNSTREAM DIRECTION.

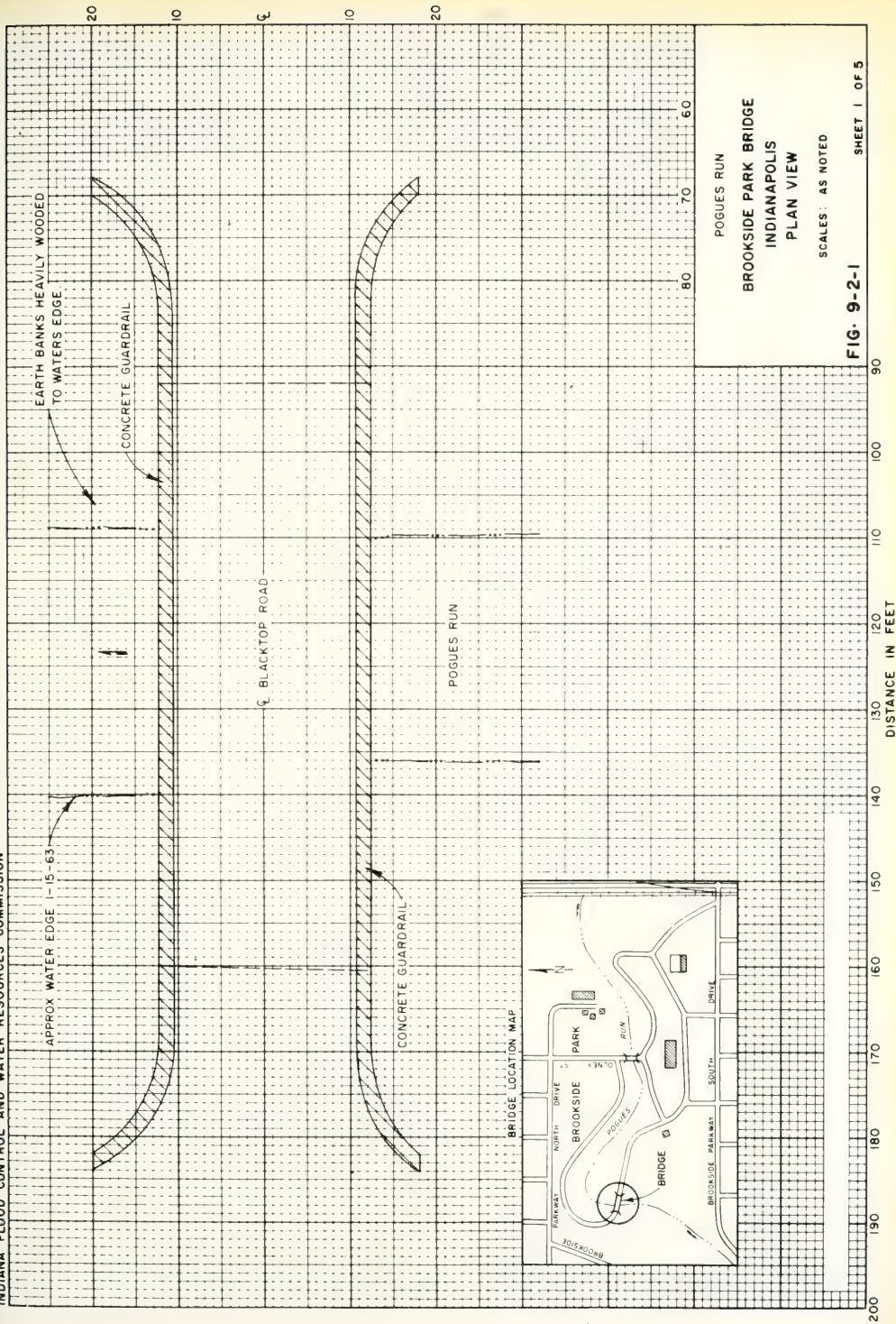
**FIG. 9-1-5**

SCALES: AS NOTED

SHEET 5 OF 5









CROWN OF ROAD

CONCRETE GUARDRAIL

CONCRETE BRIDGE

W.S. 1-15-63

POQUES RUN

BROOKSIDE PARK BRIDGE  
INDIANAPOLIS  
UPSTREAM FACE

SCALES: AS NOTED

FIG 9-2-2

SHEET 2 OF 5

NOTE: ALL SECTIONS ARE PLOTTED LOOKING IN DOWNSTREAM DIRECTION

DISTANCE IN FEET

200

190

180

170

160

150

140

130

120

110

100

90



CROWN OF ROAD

CONCRETE GUARDRAIL

CONCRETE BRIDGE

WS 1-15-63

GROUND

POGUES RUN

BROOKSIDE PARK BRIDGE  
INDIANAPOLIS  
DOWNSTREAM SIDE

SCALES - AS NOTED

FIG. 9-2-3

SHEET 3 OF 5

NOTE: ALL SECTIONS ARE PLOTTED LOOKING IN DOWNSTREAM DIRECTION

90

100

110

120

130

140

150

160

170

180

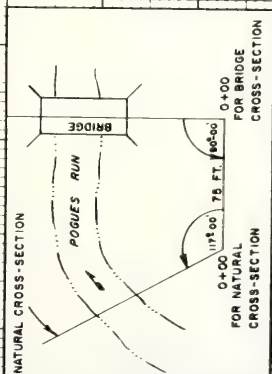
190

200

DISTANCE IN FEET







NOTE: ALL SECTIONS ARE PLOTTED LOOKING IN DOWNSTREAM DIRECTION

POGUES RUN  
 BROOKSIDE PARK BRIDGE  
 INDIANAPOLIS  
 NATURAL CROSS-SECTION  
 UPSTREAM  
 SCALES: AS NOTED

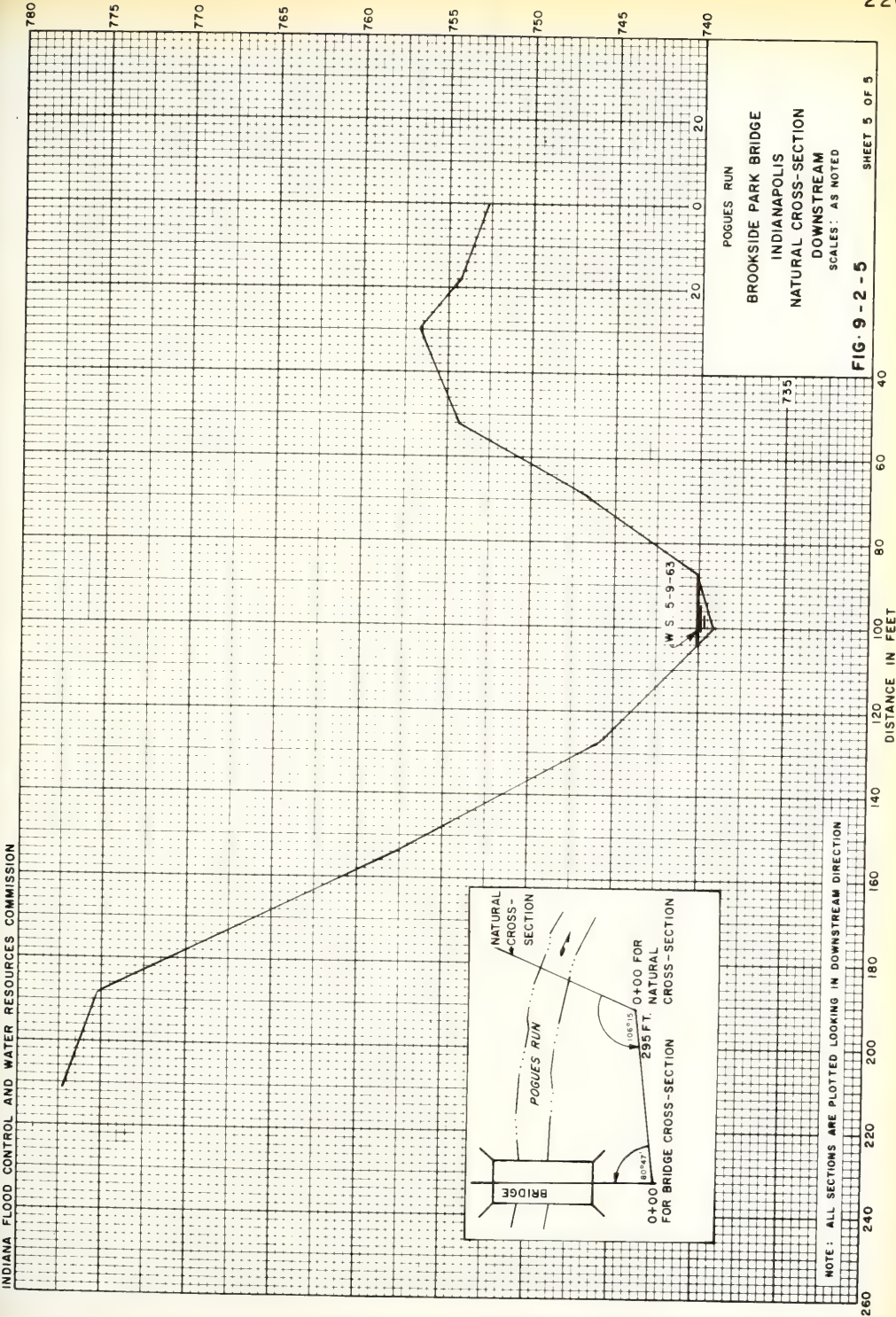
FIG. 9-2-4

SHEET 4 OF 5

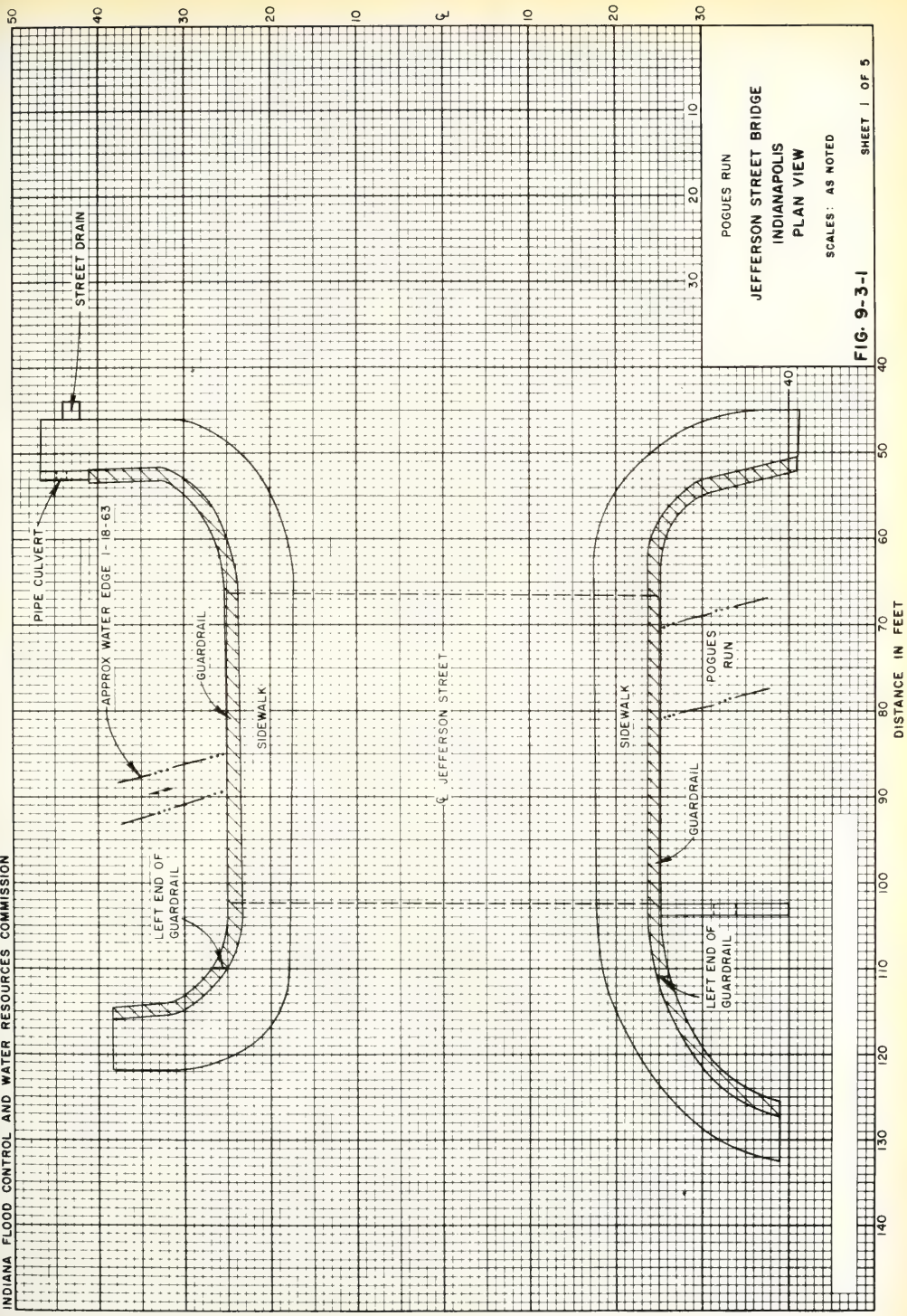
DISTANCE IN FEET





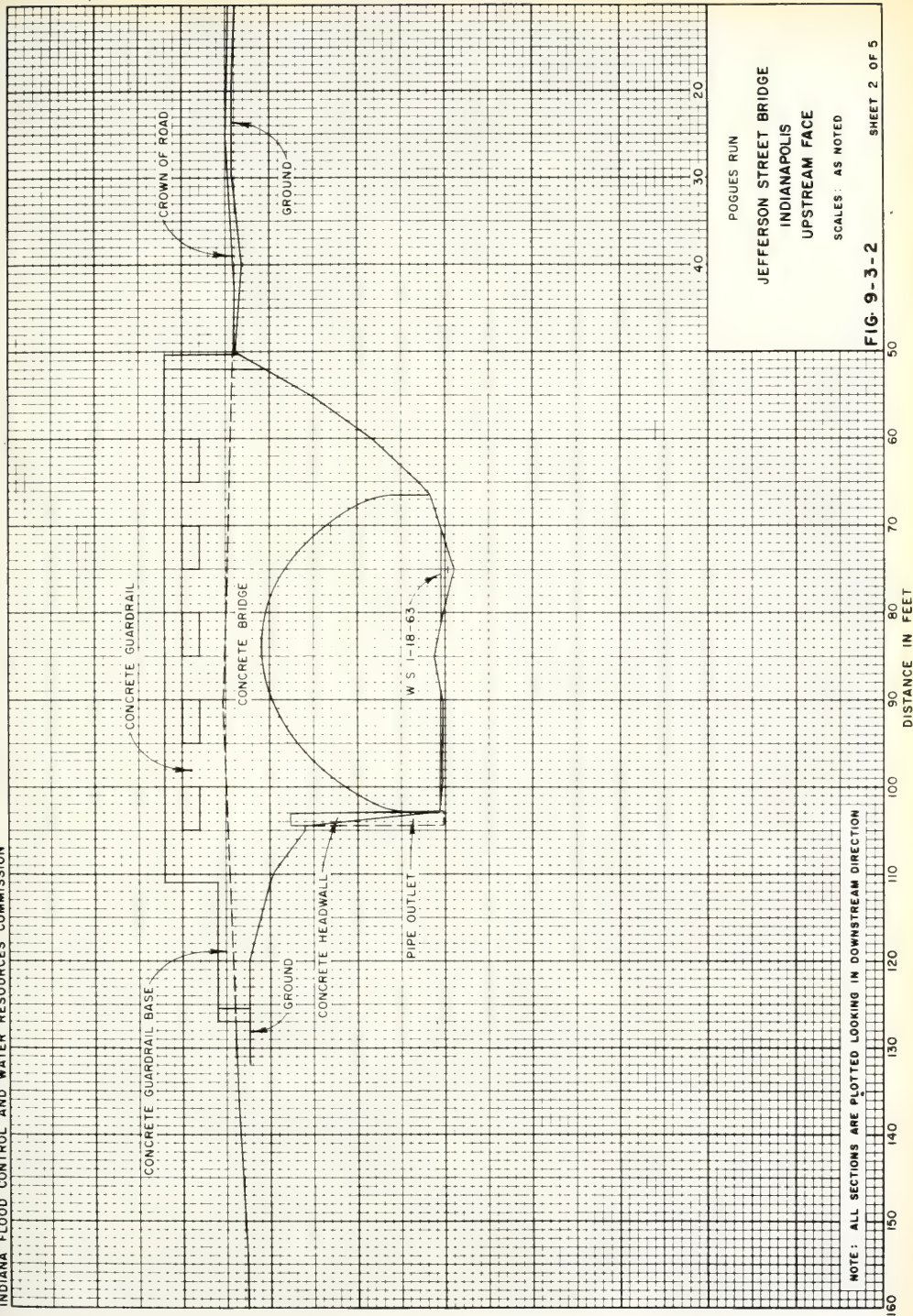




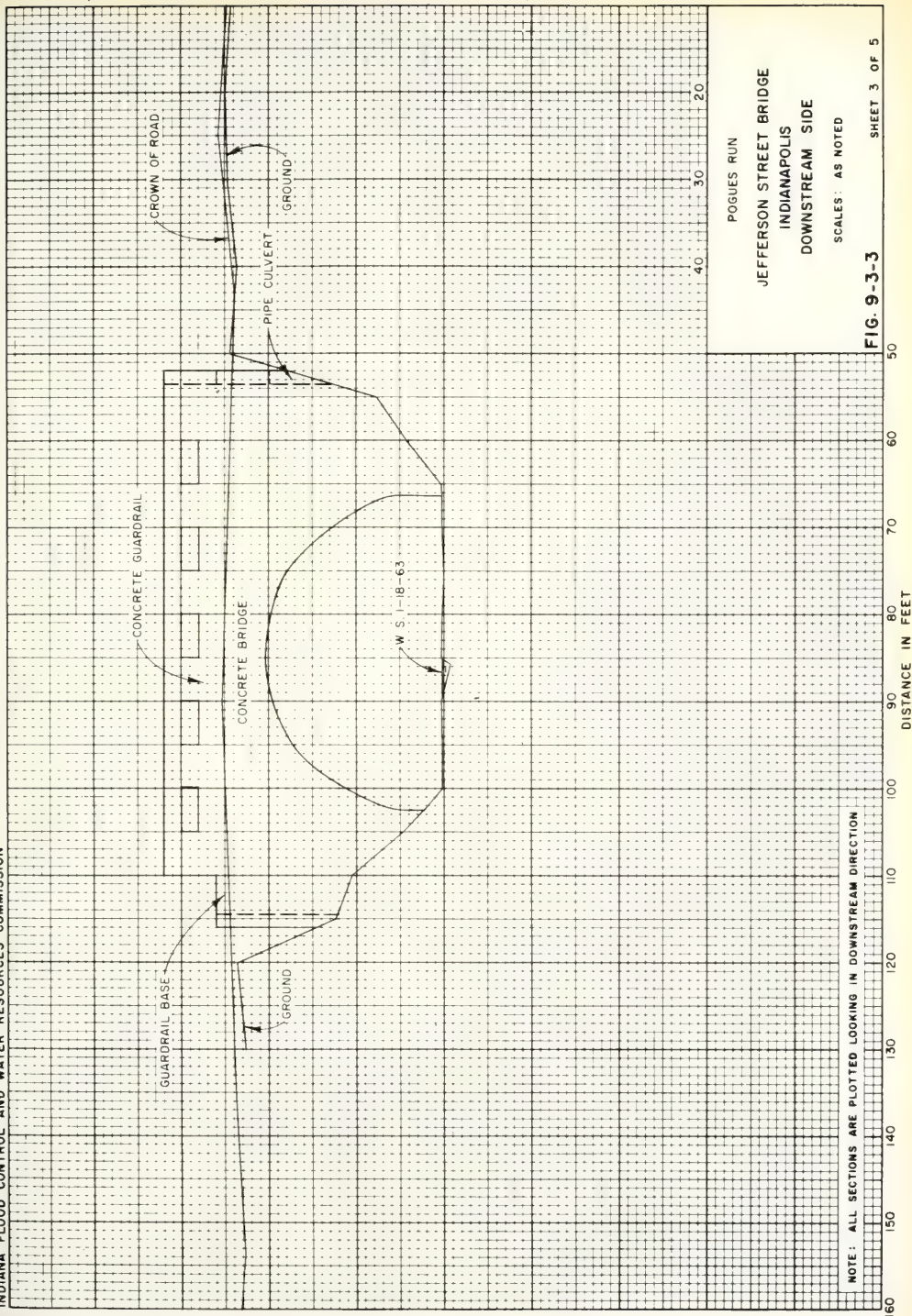








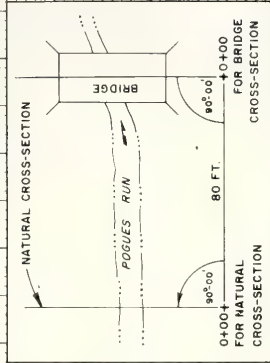








W.S. 1-18-63



POGUES RUN  
JEFFERSON STREET BRIDGE  
INDIANAPOLIS  
NATURAL CROSS-SECTION  
DOWNSTREAM  
SCALE: AS NOTED

NOTE: ALL SECTIONS ARE PLOTTED LOOKING IN DOWNSTREAM DIRECTION

FIG. 9-3-4

SHEET 4 OF 5

DISTANCE IN FEET

30

40

50

60

70

80

90

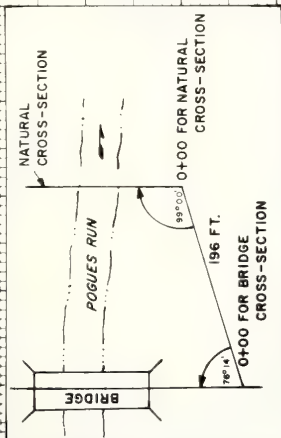
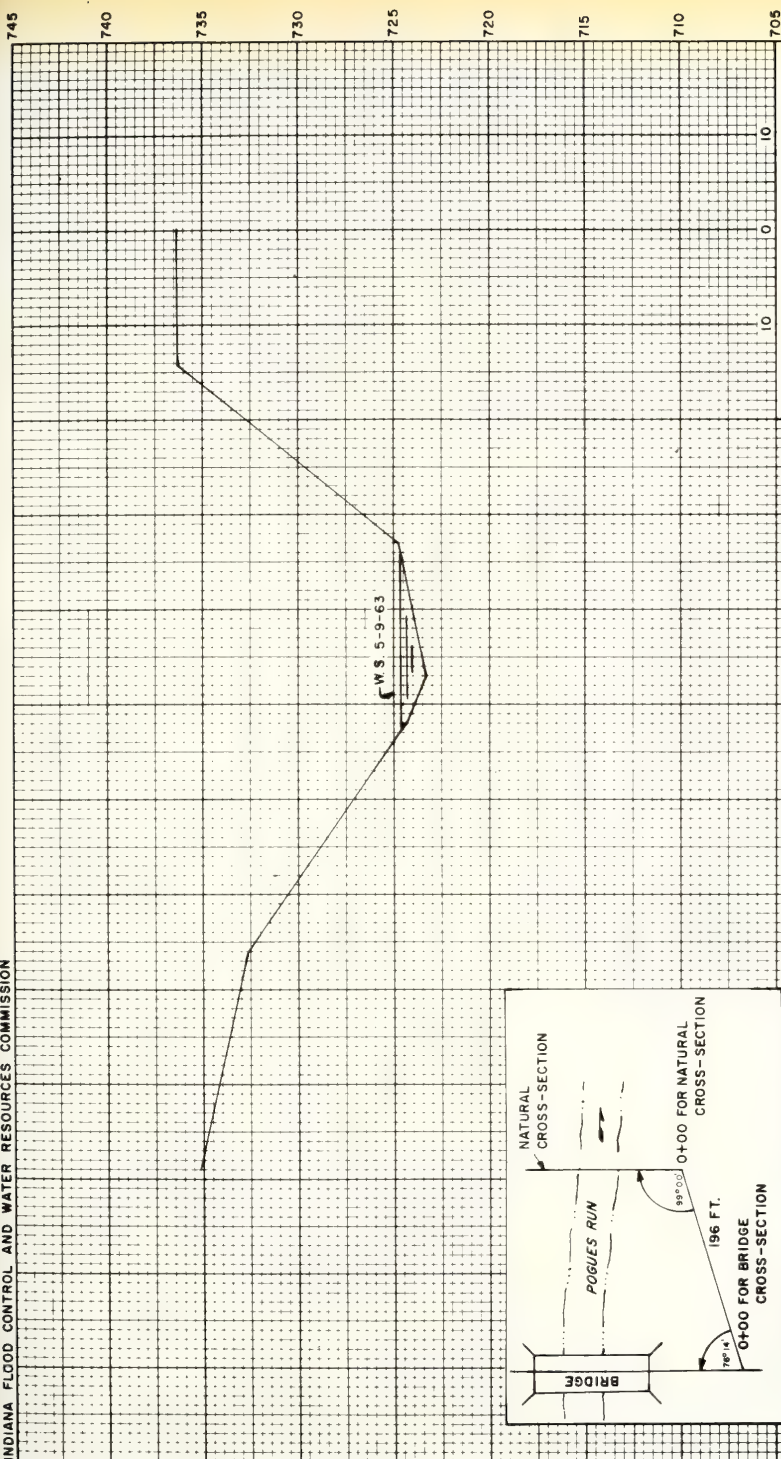
100

110

120

130





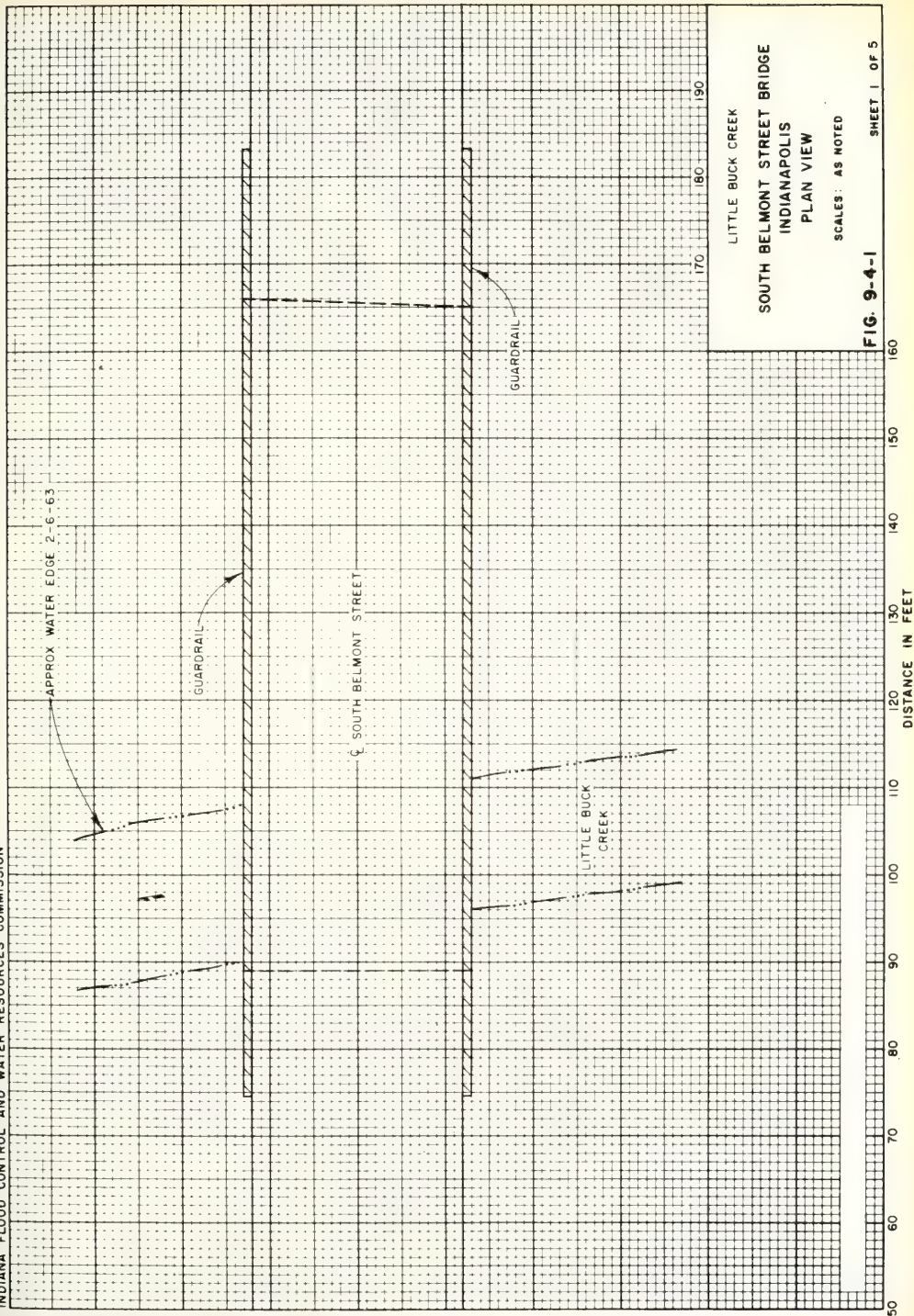
NOTE: ALL SECTIONS ARE PLOTTED LOOKING IN DOWNSTREAM DIRECTION

POGUES RUN  
JEFFERSON STREET BRIDGE  
INDIANAPOLIS  
NATURAL CROSS-SECTION  
UPSTREAM  
SCALES: AS NOTED

FIG. 9-3-5

SHEET 5 OF 5





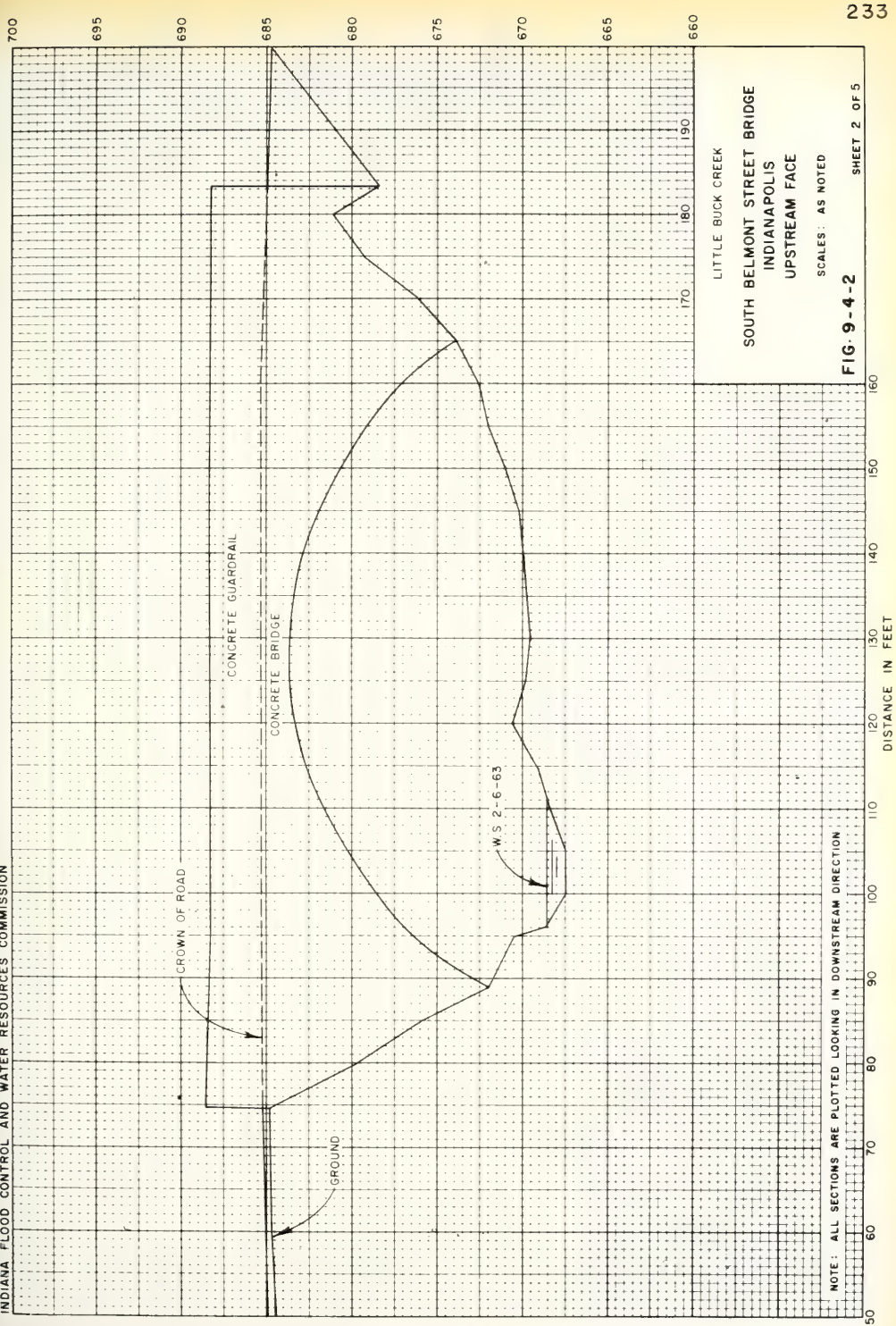
LITTLE BUCK CREEK  
SOUTH BELMONT STREET BRIDGE  
INDIANAPOLIS  
PLAN VIEW  
SCALES: AS NOTED

FIG. 9-4-1 SHEET 1 OF 5

DISTANCE IN FEET







LITTLE BUCK CREEK

**SOUTH BELMONT STREET BRIDGE  
INDIANAPOLIS  
UPSTREAM FACE**

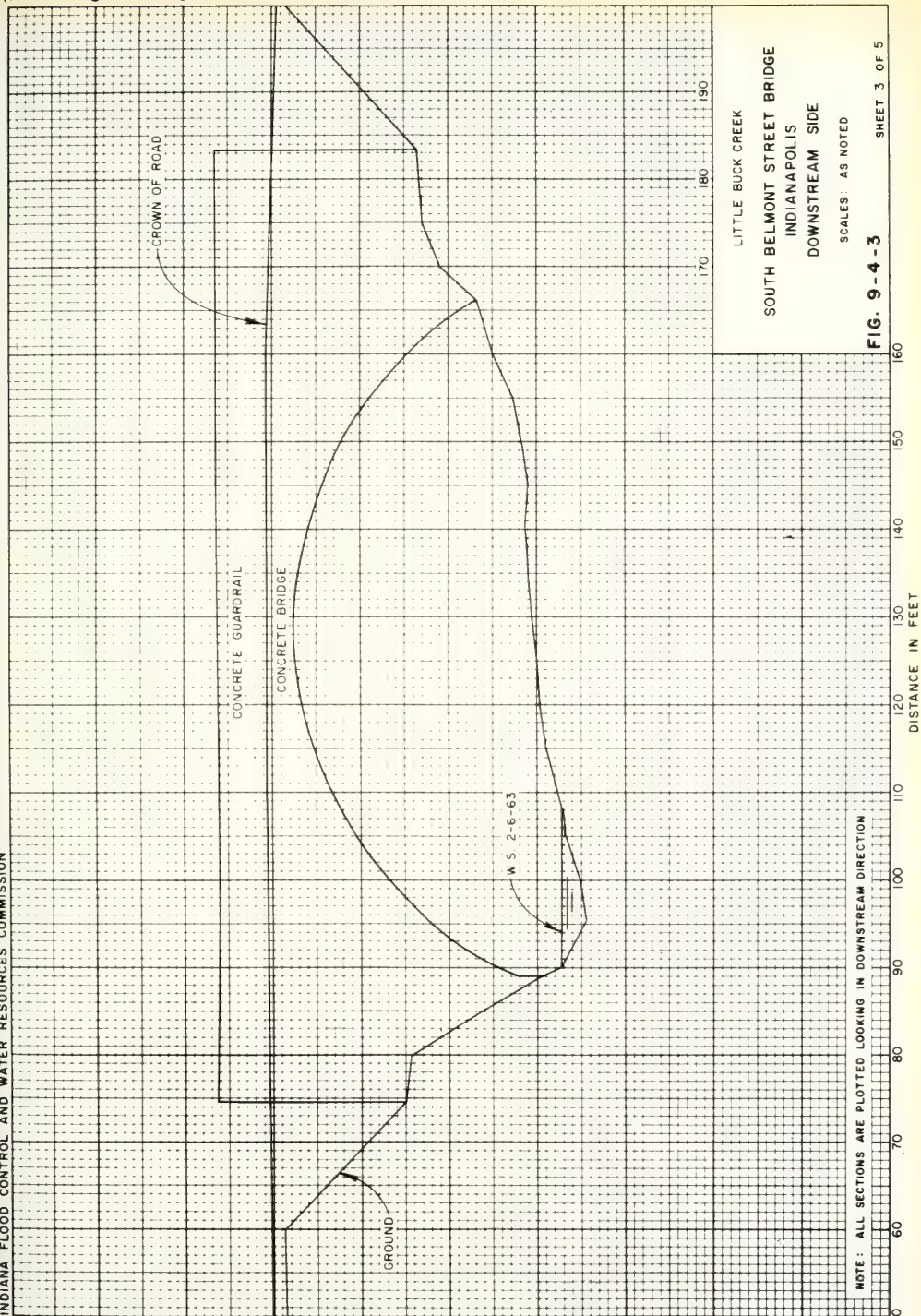
SCALES: AS NOTED

**FIG. 9-4-2**

SHEET 2 OF 5







ELEVATION (M.S.L., 1929 ADJ.)

NOTE: ALL SECTIONS ARE PLOTTED LOOKING IN DOWNSTREAM DIRECTION

FIG. 9-4-3

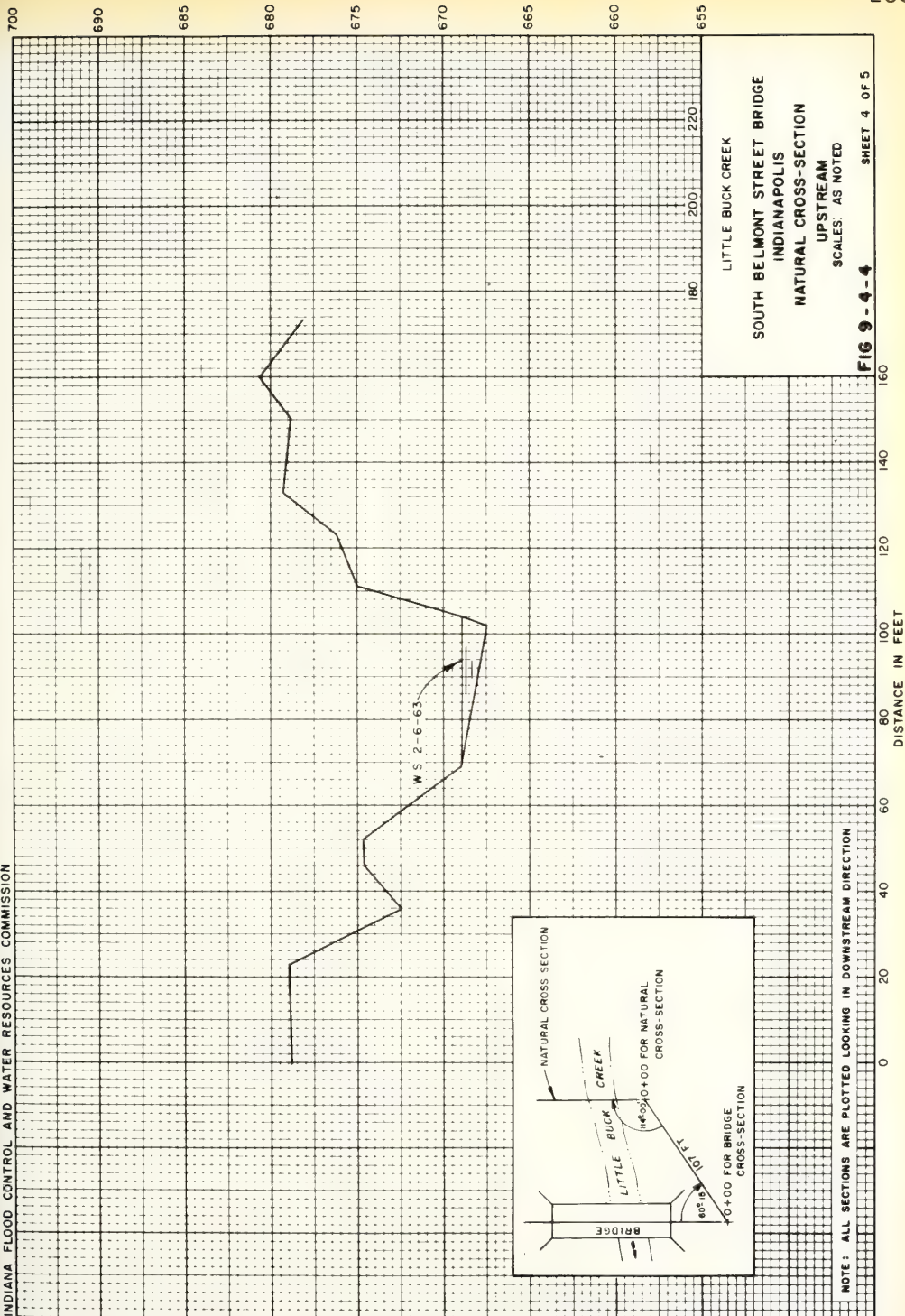
SCALES: AS NOTED

LITTLE BUCK CREEK  
SOUTH BELMONT STREET BRIDGE  
INDIANAPOLIS  
DOWNSTREAM SIDE

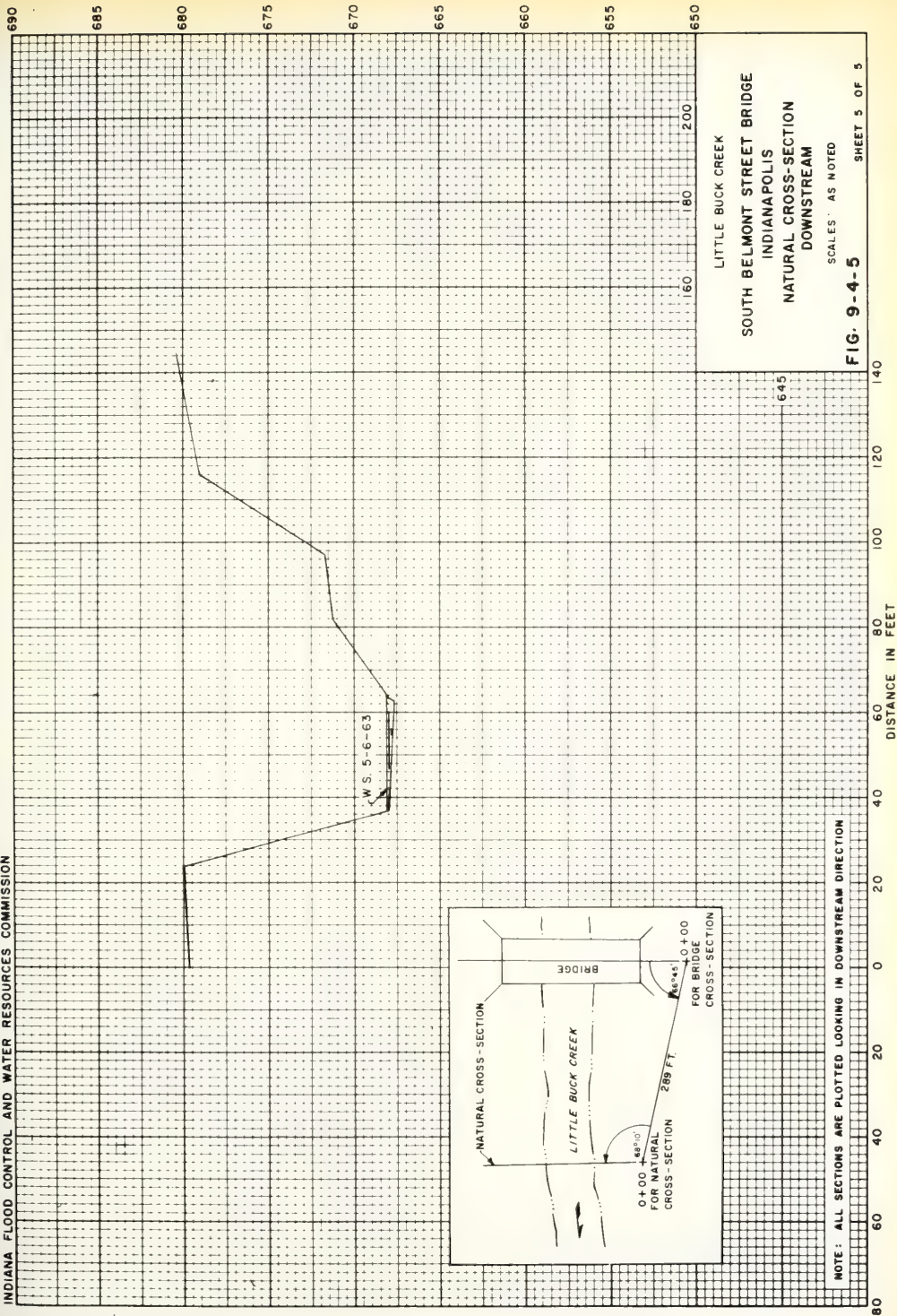
DISTANCE IN FEET

SHEET 3 OF 5





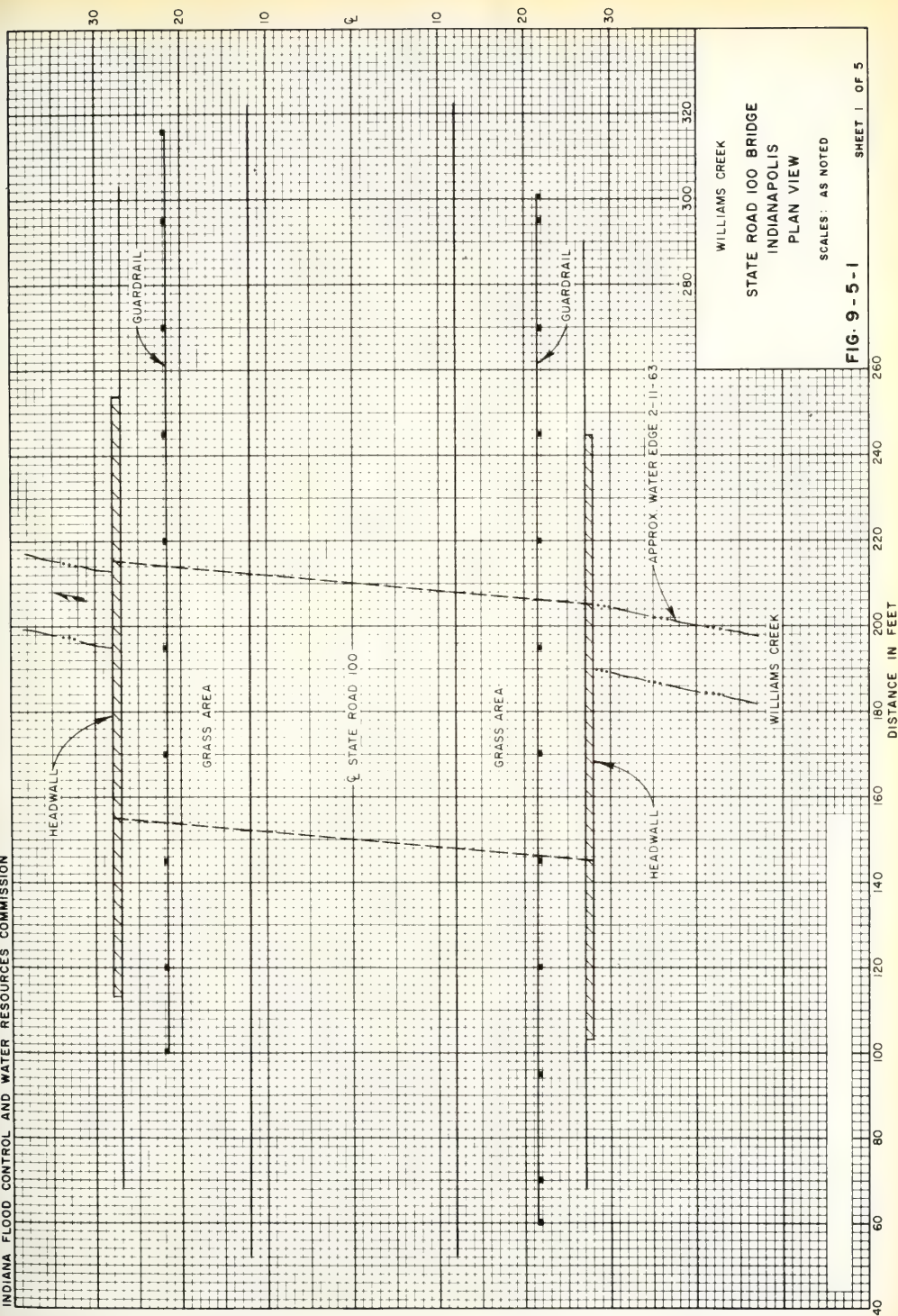




NOTE: ALL SECTIONS ARE PLOTTED LOOKING IN DOWNSTREAM DIRECTION











CROWN OF ROAD

GUARDRAIL

DIRT AND GRASS

CONCRETE BRIDGE

GROUND

W S 2-11-63

WILLIAMS CREEK

STATE ROAD 100 BRIDGE

INDIANAPOLIS

UPSTREAM FACE

SCALES AS NOTED

NOTE: ALL SECTIONS ARE PLOTTED LOOKING IN DOWNSTREAM DIRECTION

FIG. 9-5-2

SHEET 2 OF 5

210

200

190

180

170

160

150

140

130

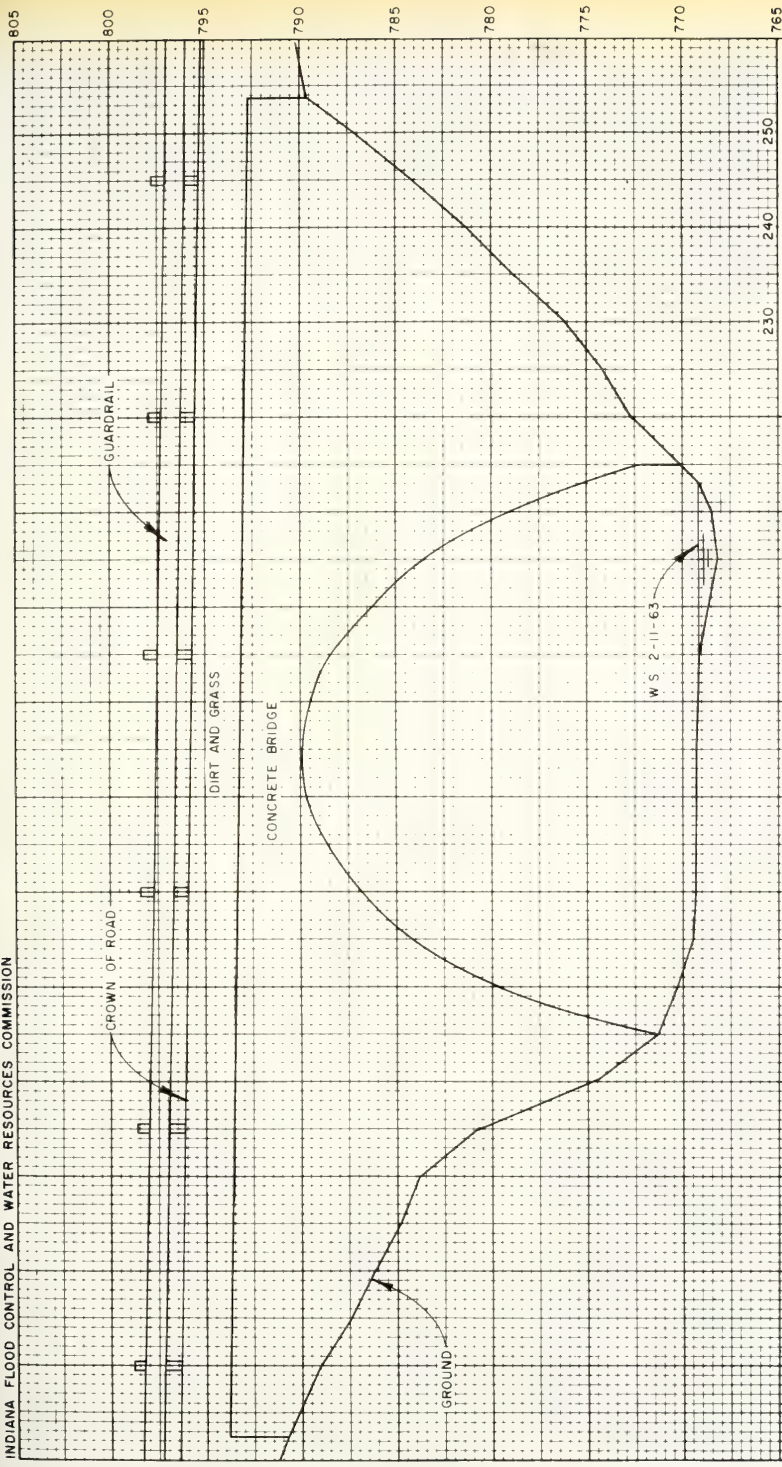
120

110

100

DISTANCE IN FEET





WILLIAMS CREEK  
STATE ROAD 100 BRIDGE  
INDIANAPOLIS  
DOWNSTREAM SIDE

SCALES: AS NOTED

NOTE: ALL SECTIONS ARE PLOTTED LOOKING IN DOWNSTREAM DIRECTION

FIG. 9-5-3

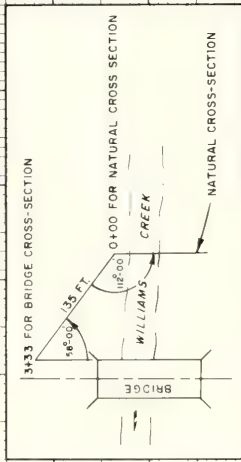


NOTE: ALL SECTIONS ARE PLOTTED LOOKING IN DOWNSTREAM DIRECTION

FIG. 9-5-4

SHEET 4 OF 5

WILLIAMS CREEK  
STATE ROAD 100 BRIDGE  
INDIANAPOLIS  
NATURAL CROSS SECTION  
UPSTREAM  
SCALES - AS NOTED



WS 2-11-63

765

20

0

-20

770

775

780

785

790

795

800

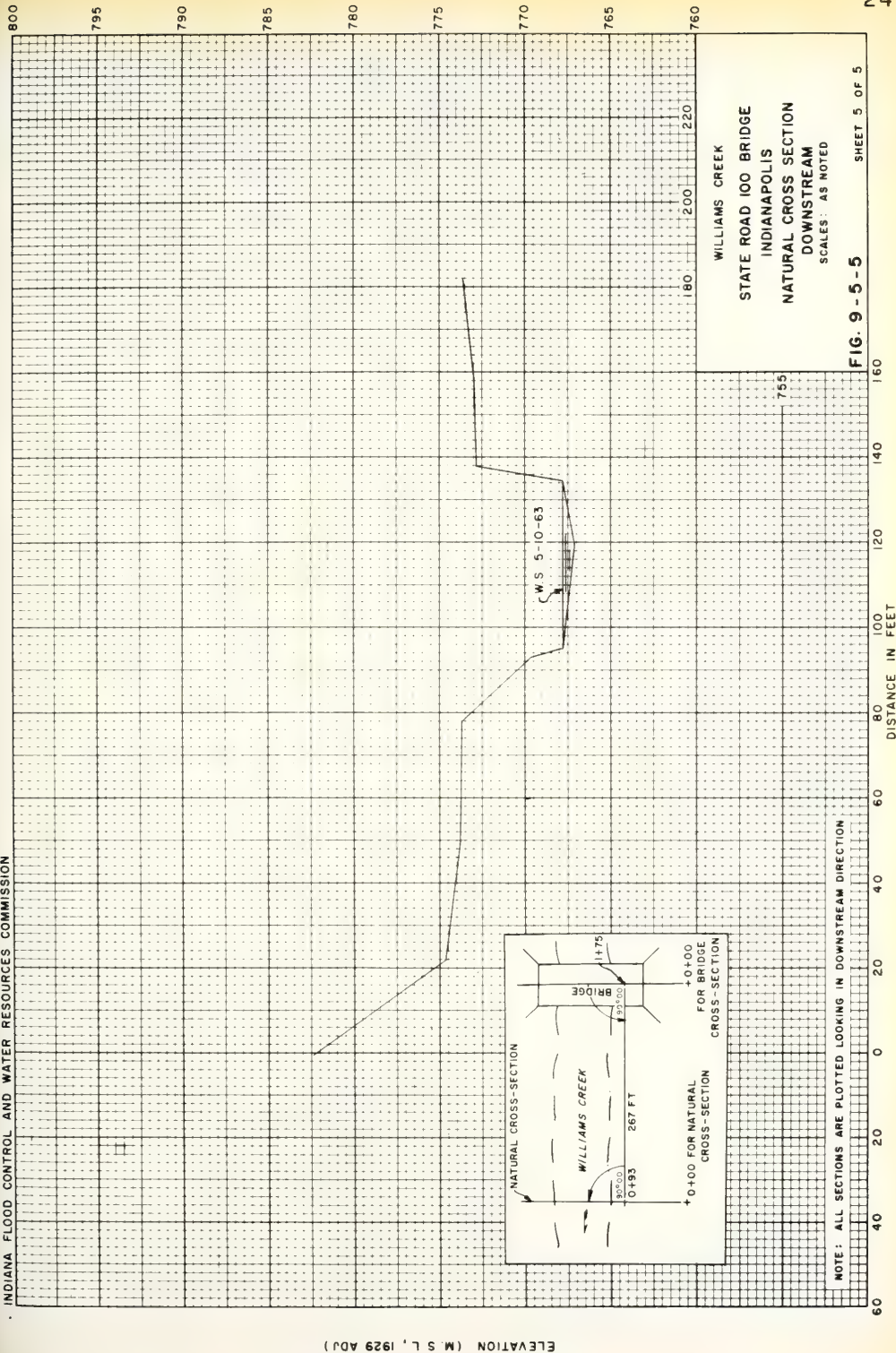
805

810

DISTANCE IN FEET

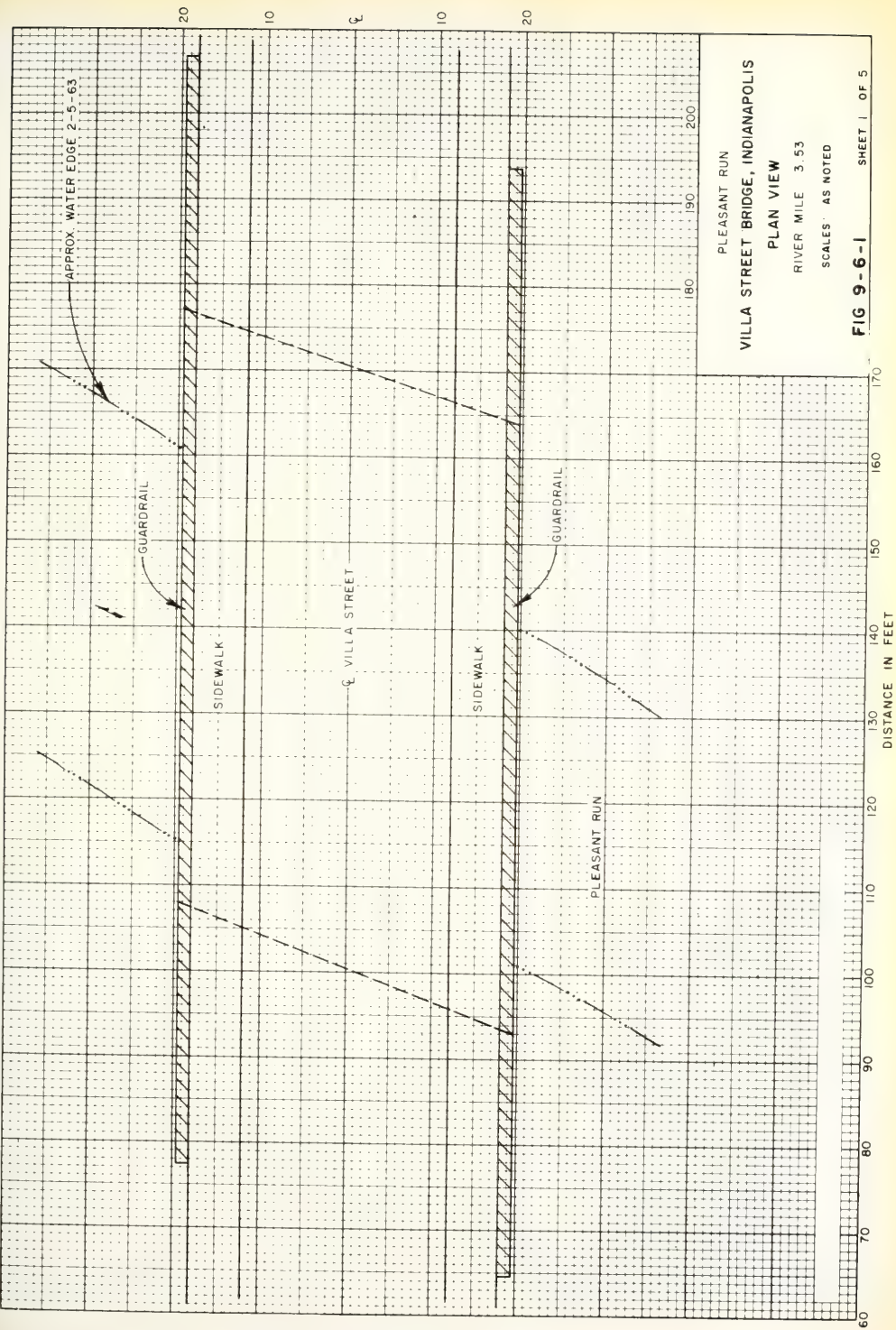














CROWN OF ROAD

CONCRETE GUARDRAIL

CONCRETE BRIDGE

GROUND

W S 2-5-63

PLEASANT RUN

VILLA STREET BRIDGE, INDIANAPOLIS

UPSTREAM FACE

RIVER MILE 3.53

SCALES AS NOTED

NOTE: ALL SECTIONS ARE PLOTTED LOOKING IN DOWNSTREAM DIRECTION

FIG 9-6-2

SHEET 2 OF 5

DISTANCE IN FEET

170

160

150

140

130

120

110

100

90

80

70

60



CROWN OF ROAD

CONCRETE GUARDRAIL

CONCRETE BRIDGE

GROUND

W S 2-5-63

PLEASANT RUN  
 VILLA STREET BRIDGE, INDIANAPOLIS  
 DOWNSTREAM SIDE  
 RIVER MILE 3.53  
 SCALES: AS NOTED

NOTE: ALL SECTIONS ARE PLOTTED LOOKING IN DOWNSTREAM DIRECTION.

FIG 9-6-3 SHEET 3 OF 5

DISTANCE IN FEET

170

160

150

140

130

120

110

100

90

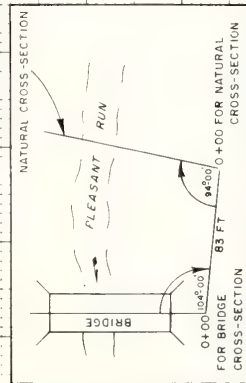
80

70

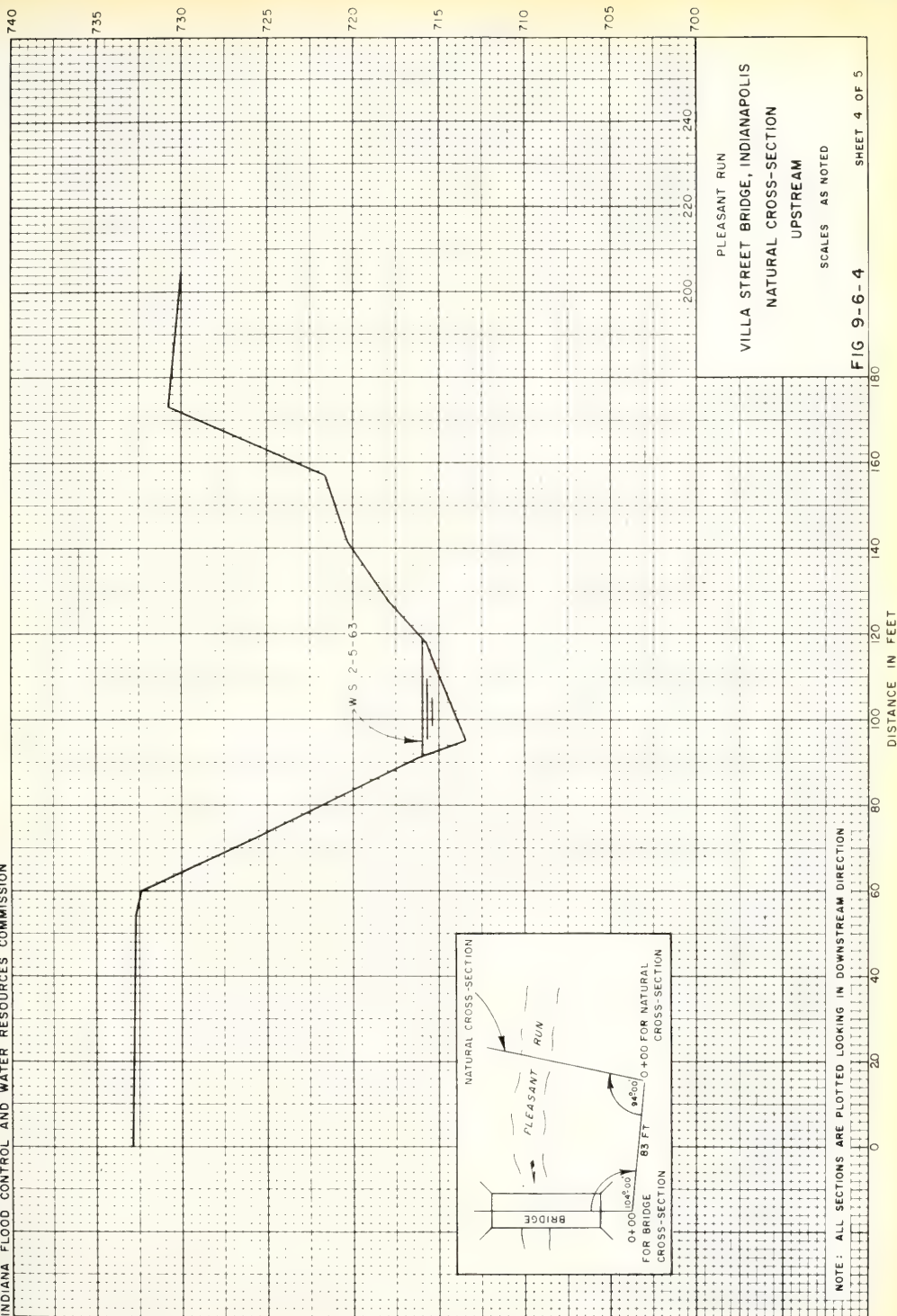
60







NOTE: ALL SECTIONS ARE PLOTTED LOOKING IN DOWNSTREAM DIRECTION







740

735

730

725

720

715

710

705

700

PLEASANT RUN

# VILLA STREET BRIDGE, INDIANAPOLIS NATURAL CROSS-SECTION

DOWNSTREAM

 RIVER MILE: 3.53  
 SCALES: AS NOTED

FIG 9-6-5

SHEET 5 OF 5

60

50

40

30

20

10

0

10

20

30

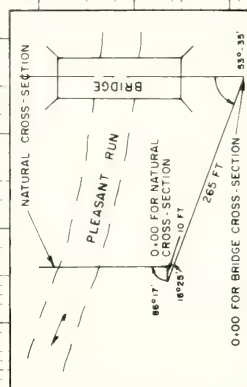
40

50

60

70

W S 7-5-63

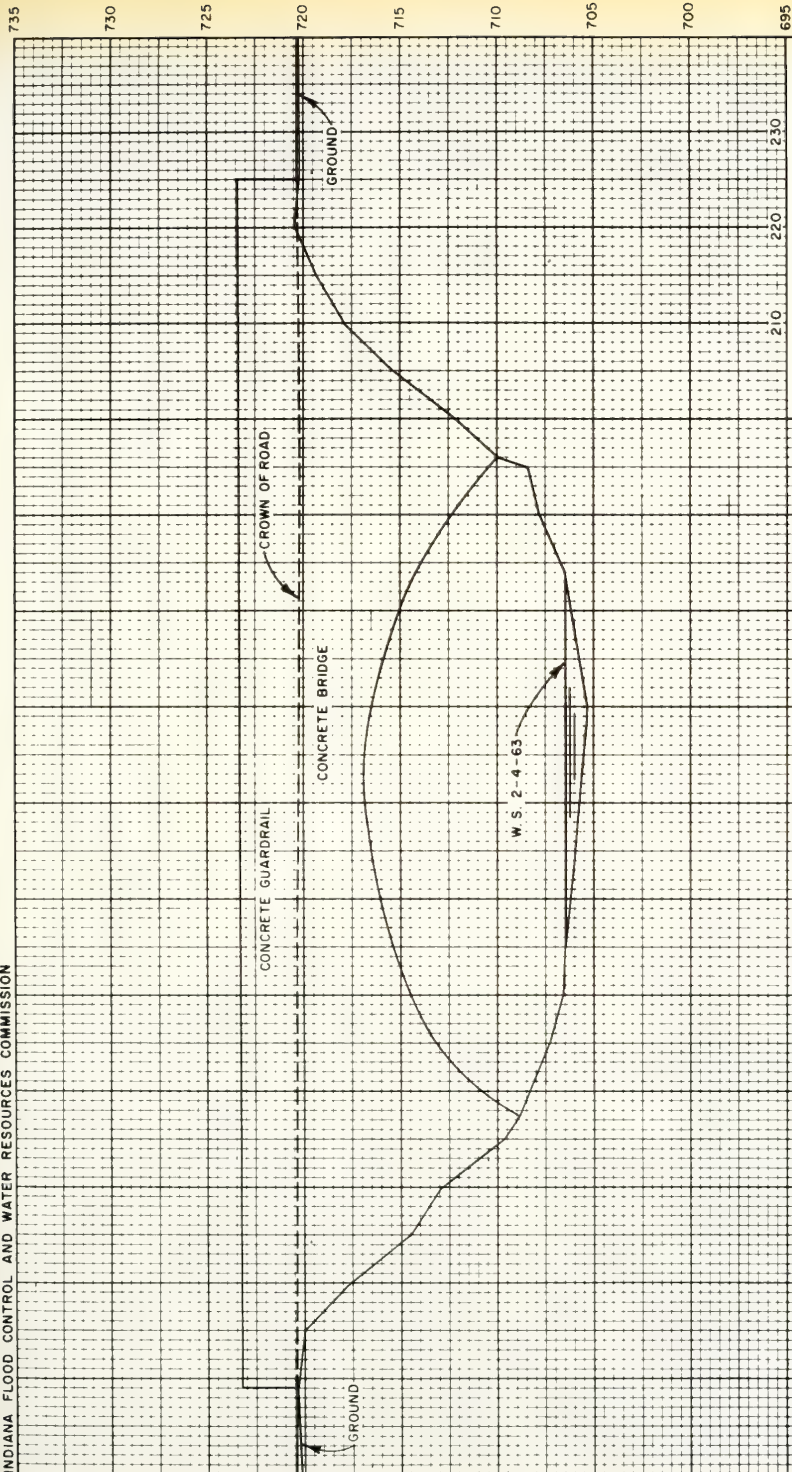


NOTE: ALL SECTIONS ARE PLOTTED LOOKING IN DOWNSTREAM DIRECTION









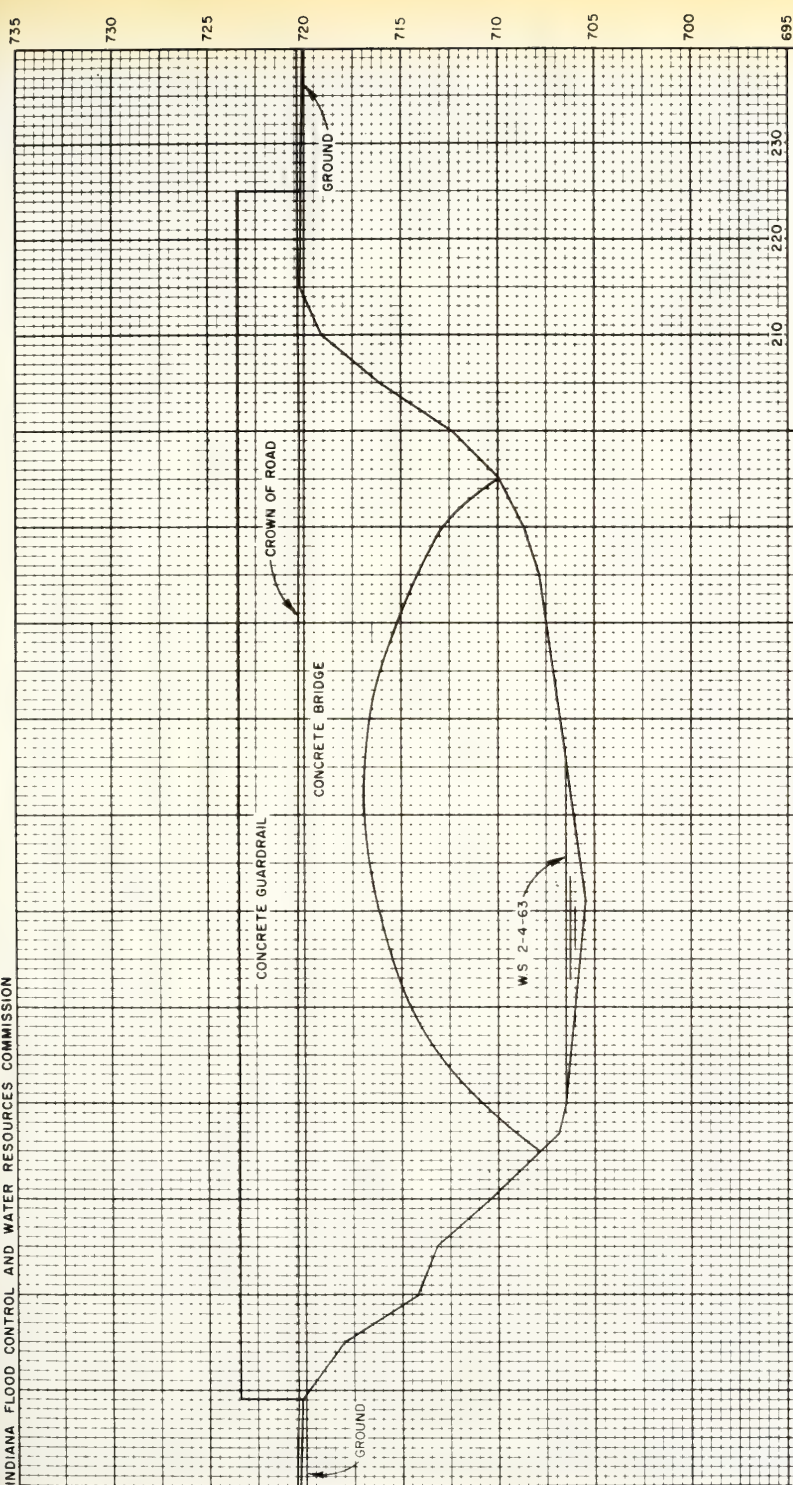
NOTE: ALL SECTIONS ARE PLOTTED LOOKING IN DOWNSTREAM DIRECTION

FIG 9-7-2

SHEET 2 OF 5







PLEASANT RUN  
 LINDEN STREET BRIDGE, INDIANAPOLIS  
 DOWNSTREAM SIDE  
 RIVER MILE 2.83  
 SCALES: AS NOTED

NOTE: ALL SECTIONS ARE PLOTTED LOOKING IN DOWNSTREAM DIRECTION

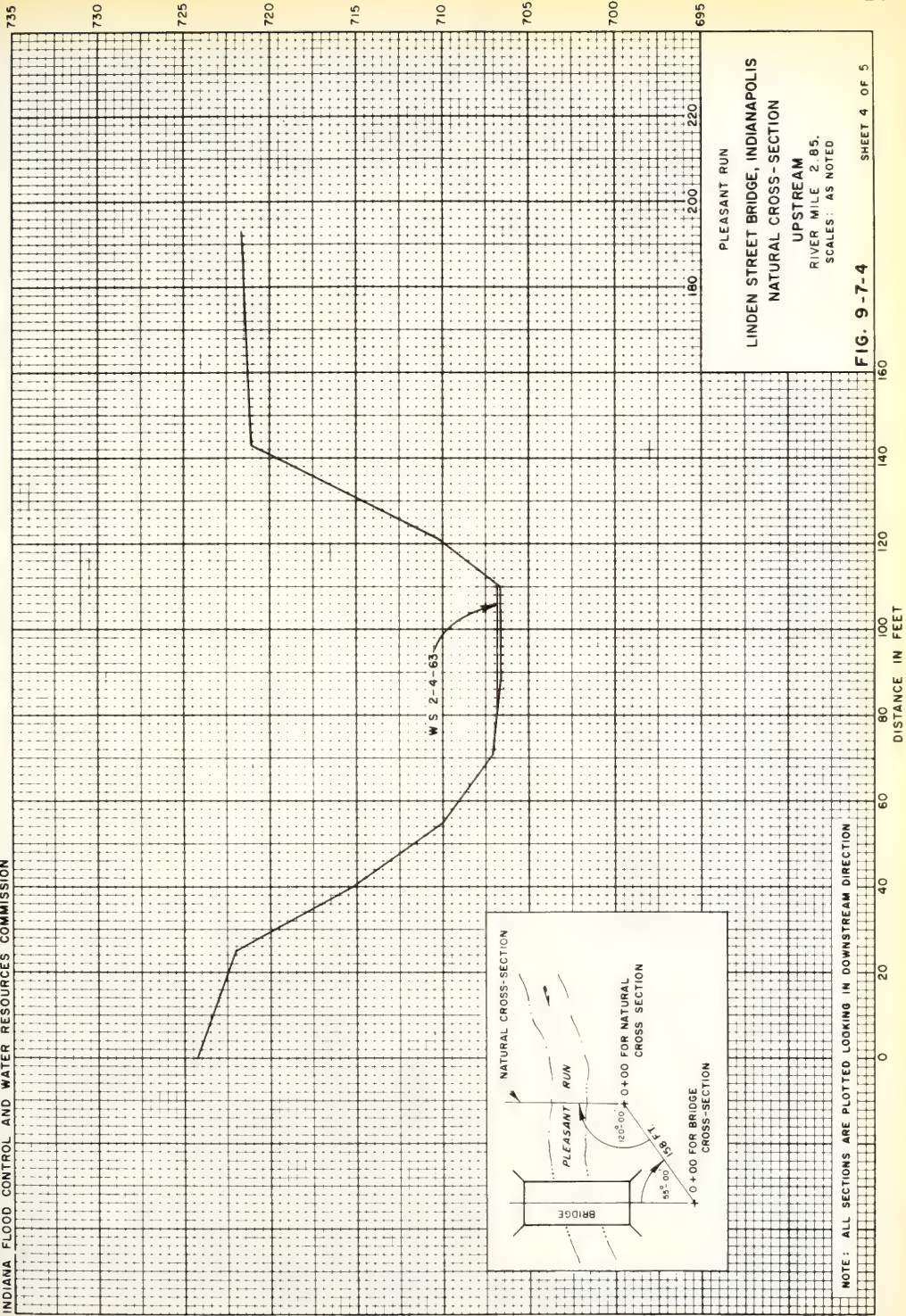
FIG. 9-7-3

SHEET 3 OF 5

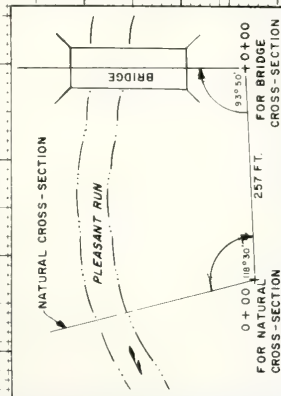
DISTANCE IN FEET











PLEASANT RUN

LINDEN STREET BRIDGE, INDIANAPOLIS

NATURAL CROSS-SECTION

DOWNSTREAM

RIVER MILE 2.78

SCALES: AS NOTED

FIG. 9-7-5

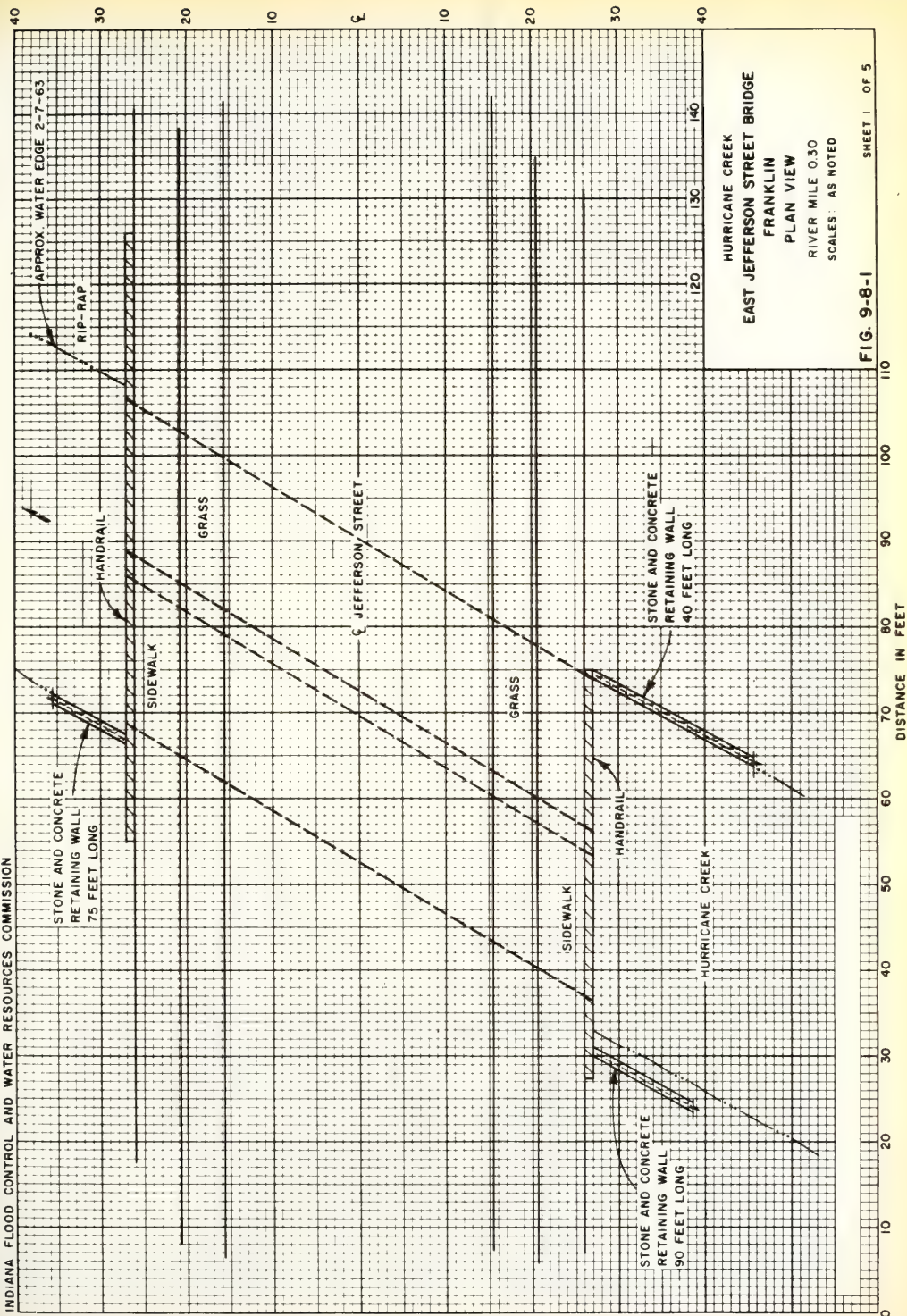
SHEET 5 OF 5

NOTE: ALL SECTIONS ARE PLOTTED LOOKING IN DOWNSTREAM DIRECTION

DISTANCE IN FEET







HURRICANE CREEK  
EAST JEFFERSON STREET BRIDGE  
FRANKLIN  
PLAN VIEW  
RIVER MILE 0.30  
SCALES: AS NOTED

FIG. 9-8-1



735

730

725

720

715

710

705

700

695

METAL AND SCREEN HANDRAIL

STONE BRIDGE

W.S. 2-7-63

GROUND

STONE AND CONCRETE  
RETAINING WALL

CROWN OF ROAD

STONE AND CONCRETE  
RETAINING WALL

HURRICANE CREEK  
EAST JEFFERSON STREET BRIDGE  
FRANKLIN  
UPSTREAM FACE  
RIVER MILE 0.30  
SCALES: AS NOTED

FIG. 9-8-2 SHEET 2 OF 5

NOTE: ALL SECTIONS ARE PLOTTED LOOKING IN DOWNSTREAM DIRECTION

DISTANCE IN FEET

70

65

60

55

50

45

40

35

30

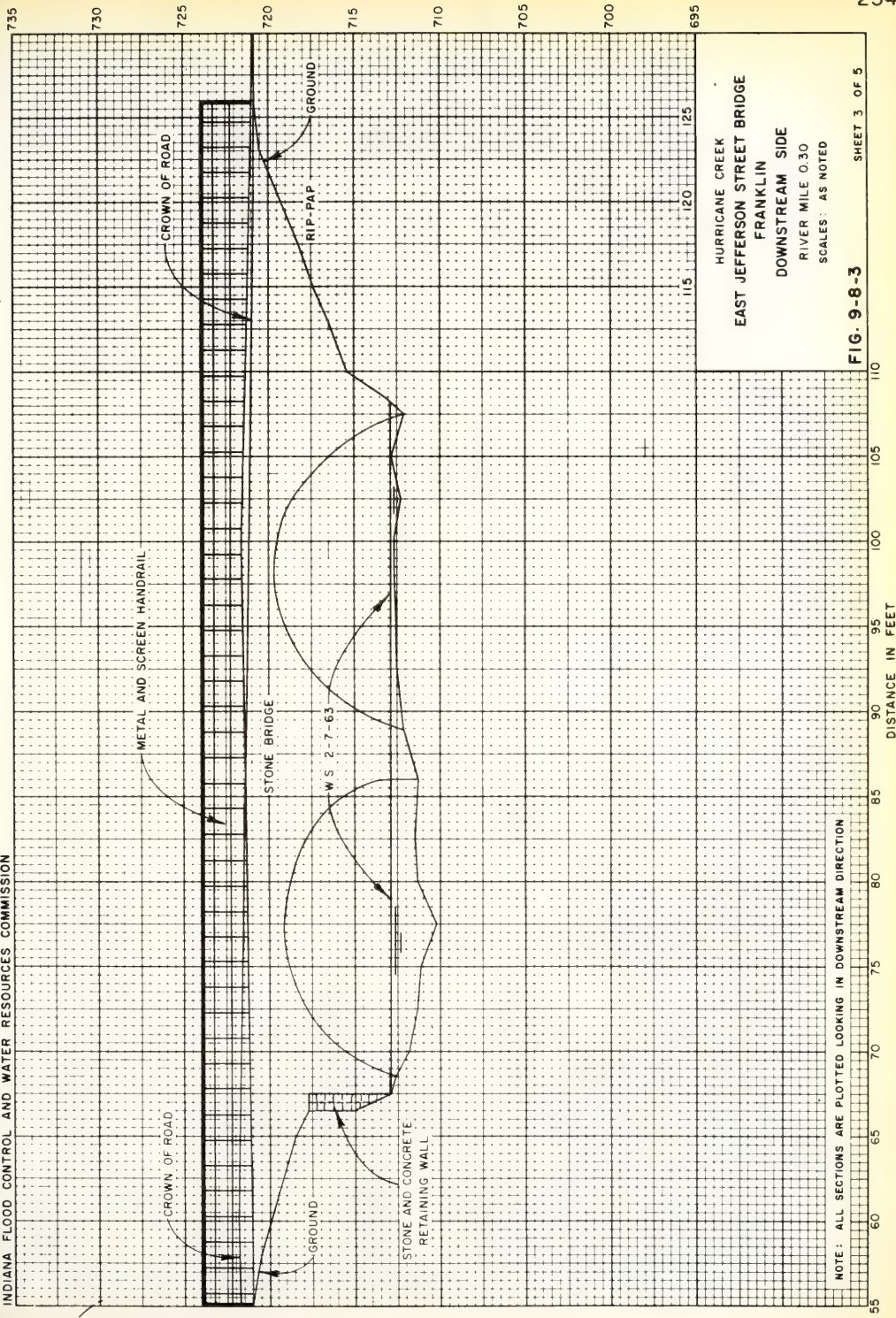
25

20

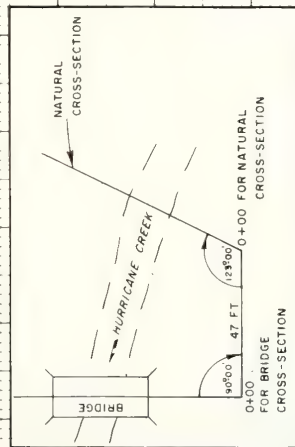
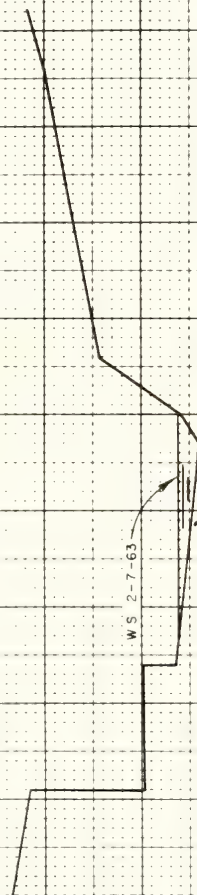
15











NOTE: ALL SECTIONS ARE PLOTTED LOOKING IN DOWNSTREAM DIRECTION

HURRICANE CREEK  
EAST JEFFERSON STREET BRIDGE  
FRANKLIN

NATURAL CROSS-SECTION  
UPSTREAM  
RIVER MILE 0.30  
SCALE: AS NOTED

FIG. 9-8-4

SHEET 4 OF 5

DISTANCE IN FEET

-30

-20

-10

0

10

20

30

40

50

60

70

80

90

100

110

120

130

140

150

160

170

180

190

200

210

220

230

240

250

260

270

280

290

300

310

320

330

340

350

360

370

380

390

400

410

420

430

440

450

460

470

480

490

500

510

520

530

540

550

560

570

580

590

600

610

620

630

640

650

660

670

680

690

700

710

720

730

740

750

760

770

780

790

800

810

820

830

840

850

860

870

880

890

900

910

920

930

940

950

960

970

980

990

1000

1010

1020

1030

1040

1050

1060

1070

1080

1090

1100

1110

1120

1130

1140

1150

1160

1170

1180

1190

1200

1210

1220

1230

1240

1250

1260

1270

1280

1290

1300

1310

1320

1330

1340

1350

1360

1370

1380

1390

1400

1410

1420

1430

1440

1450

1460

1470

1480

1490

1500

1510

1520

1530

1540

1550

1560

1570

1580

1590

1600

1610

1620

1630

1640

1650

1660

1670

1680

1690

1700

1710

1720

1730

1740

1750

1760

1770

1780

1790

1800

1810

1820

1830

1840

1850

1860

1870

1880

1890

1900

1910

1920

1930

1940

1950

1960

1970

1980

1990

2000

2010

2020

2030

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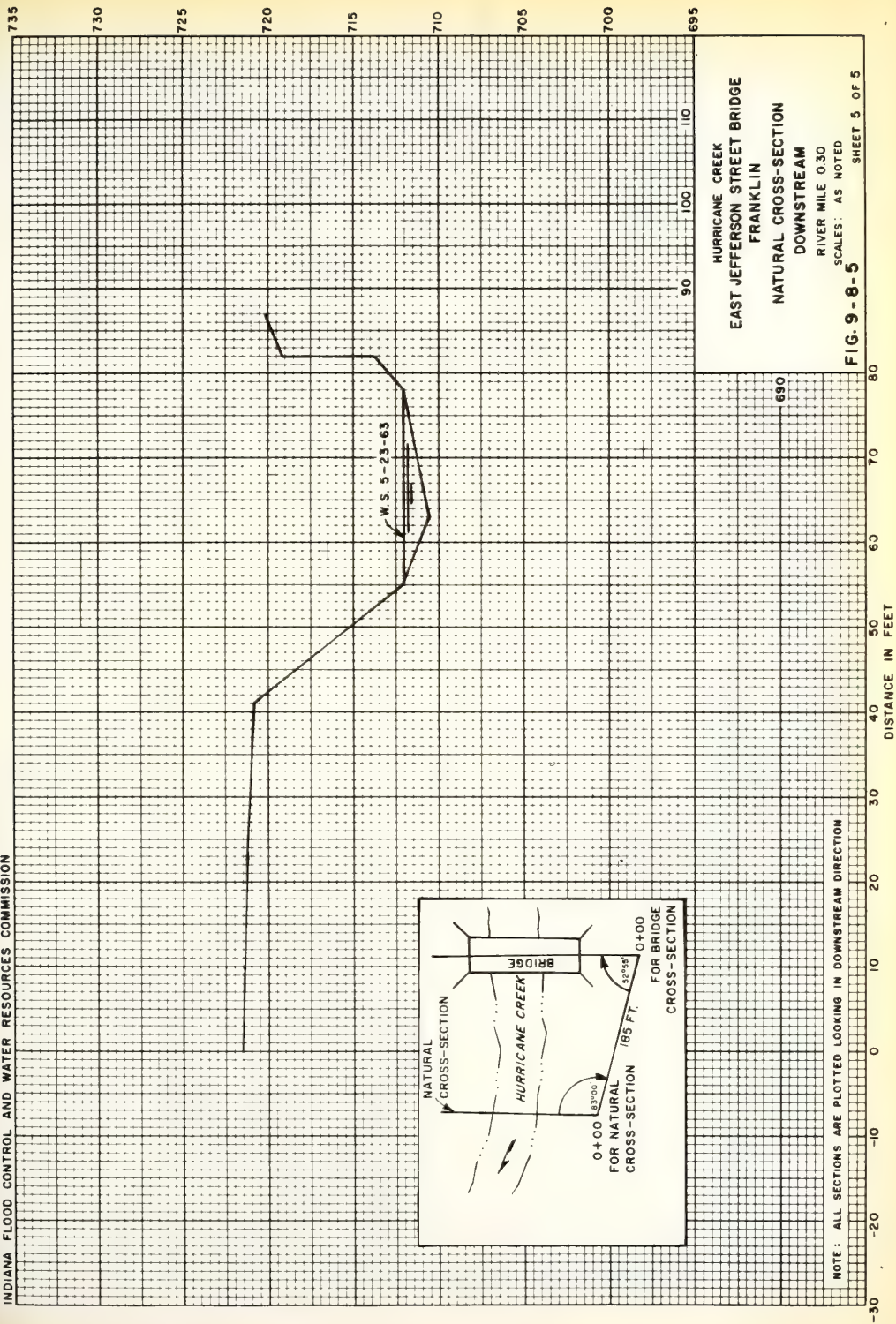
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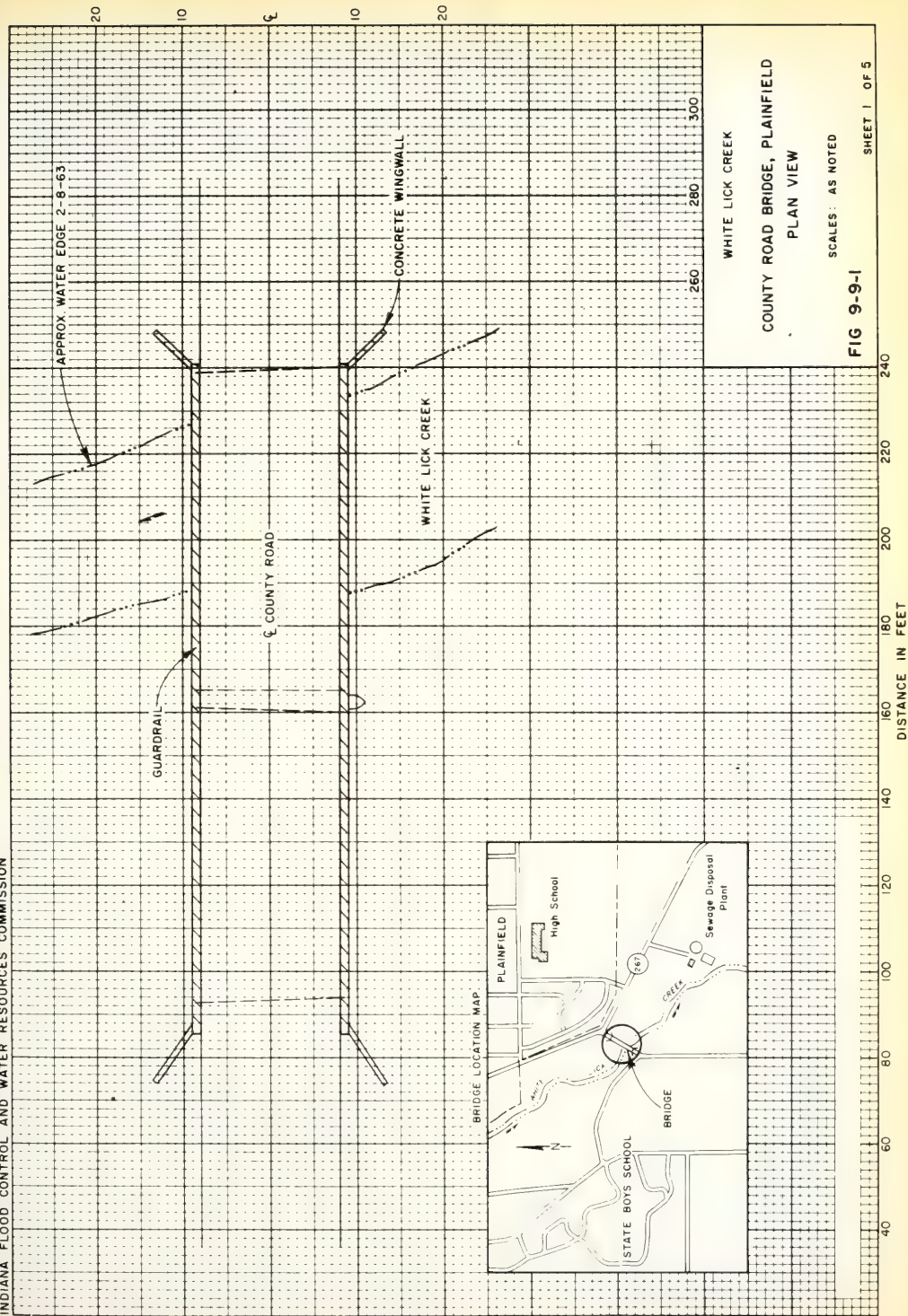


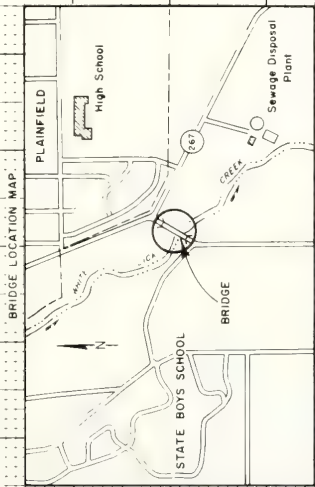
FIG 9-9-1

COUNTY ROAD BRIDGE, PLAINFIELD  
PLAN VIEW

SCALES: AS NOTED

SHEET 1 OF 5

DISTANCE IN FEET



WHITE LICK CREEK





735

730

725

720

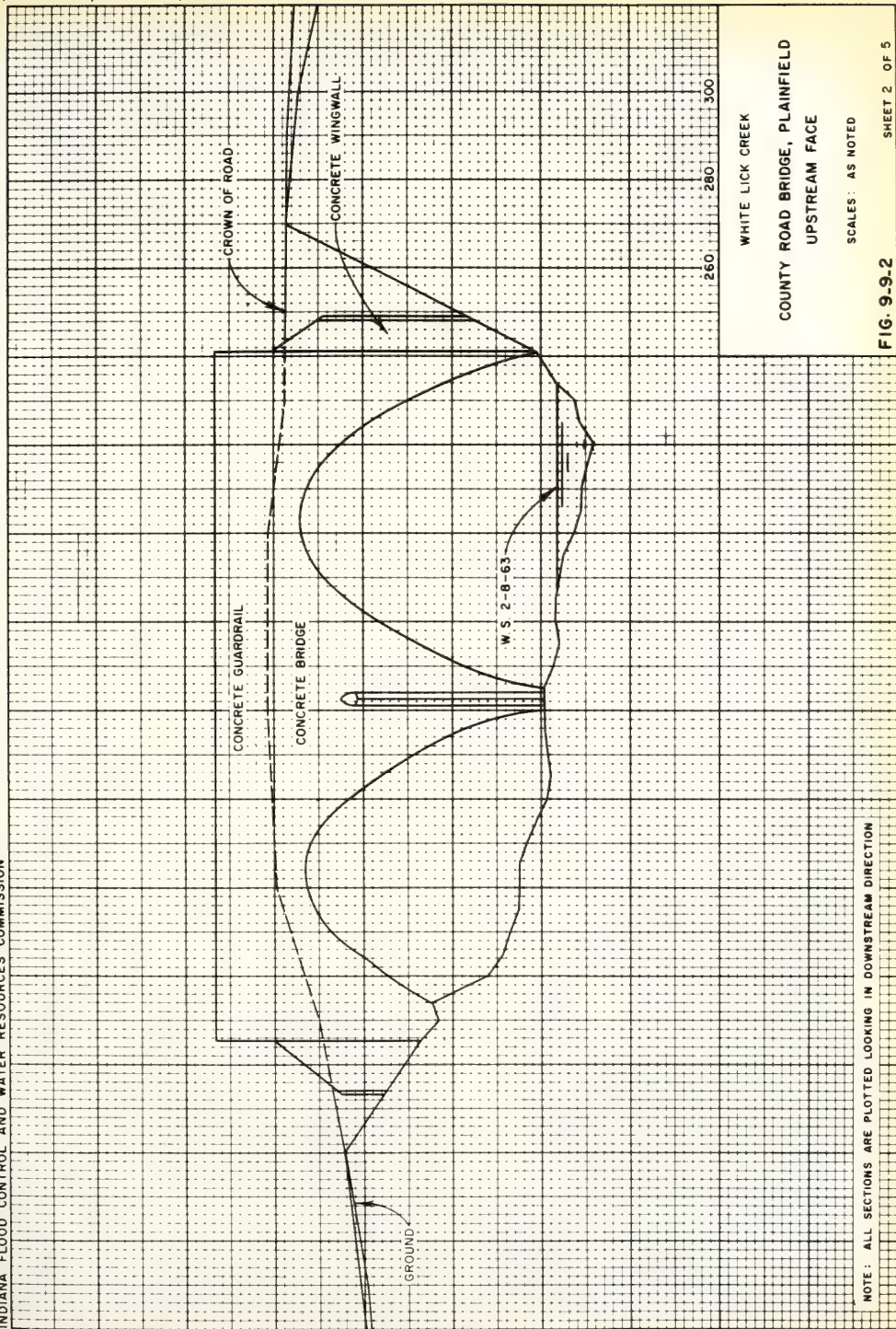
715

710

705

700

695



WHITE LICK CREEK

COUNTY ROAD BRIDGE, PLAINFIELD  
UPSTREAM FACE

SCALE: AS NOTED

FIG. 9-9-2

SHEET 2 OF 5

DISTANCE IN FEET

NOTE: ALL SECTIONS ARE PLOTTED LOOKING IN DOWNSTREAM DIRECTION

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SHEET 2 OF 5

FIG. 9-9-2

NOTE: ALL SECTIONS ARE PLOTTED LOOKING IN DOWNSTREAM DIRECTION

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SHEET 2 OF 5

FIG. 9-9-2

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SHEET 2 OF 5

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SHEET 2 OF 5

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SHEET 2 OF 5

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SHEET 2 OF 5

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SHEET 2 OF 5

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SHEET 2 OF 5

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SHEET 2 OF 5

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NOTE: ALL SECTIONS ARE PLOTTED LOOKING IN DOWNSTREAM DIRECTION

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SHEET 2 OF 5

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SHEET 2 OF 5

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SHEET 2 OF 5

FIG. 9-9-2

NOTE: ALL SECTIONS ARE PLOTTED LOOKING IN DOWNSTREAM DIRECTION

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SHEET 2 OF 5

FIG. 9-9-2

NOTE: ALL SECTIONS ARE PLOTTED LOOKING IN DOWNSTREAM DIRECTION

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SHEET 2 OF 5

FIG. 9-9-2

NOTE: ALL SECTIONS ARE PLOTTED LOOKING IN DOWNSTREAM DIRECTION

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SHEET 2 OF 5

FIG. 9-9-2

NOTE: ALL SECTIONS ARE PLOTTED LOOKING IN DOWNSTREAM DIRECTION

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240

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280

300

SHEET 2 OF 5

FIG. 9-9-2

NOTE: ALL SECTIONS ARE PLOTTED LOOKING IN DOWNSTREAM DIRECTION

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60

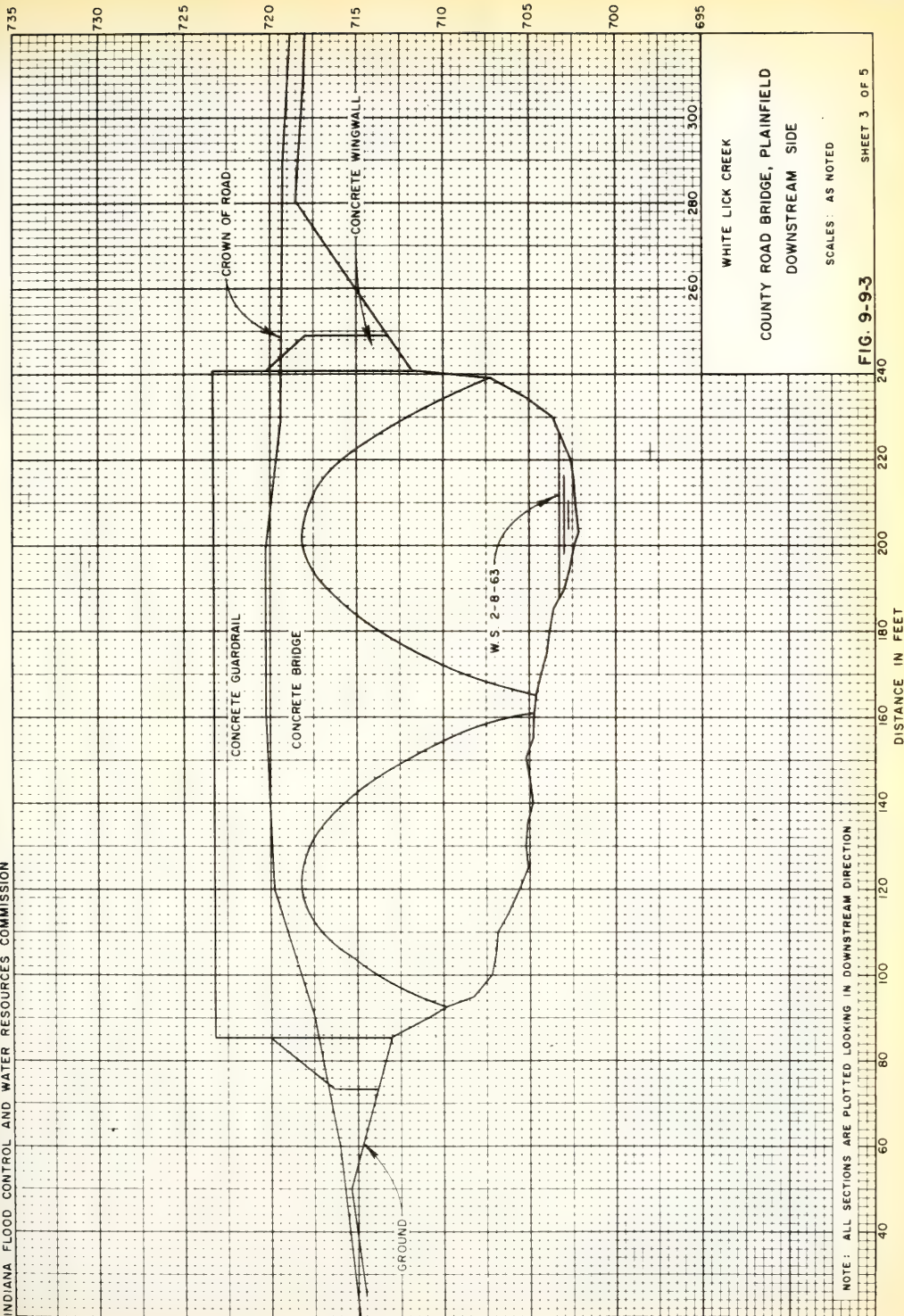
80

100

120

140





NOTE: ALL SECTIONS ARE PLOTTED LOOKING IN DOWNSTREAM DIRECTION

DISTANCE IN FEET

SHEET 3 OF 5

FIG. 9-9-3

SCALES AS NOTED

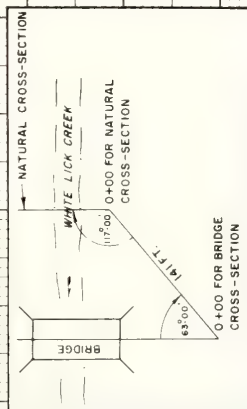
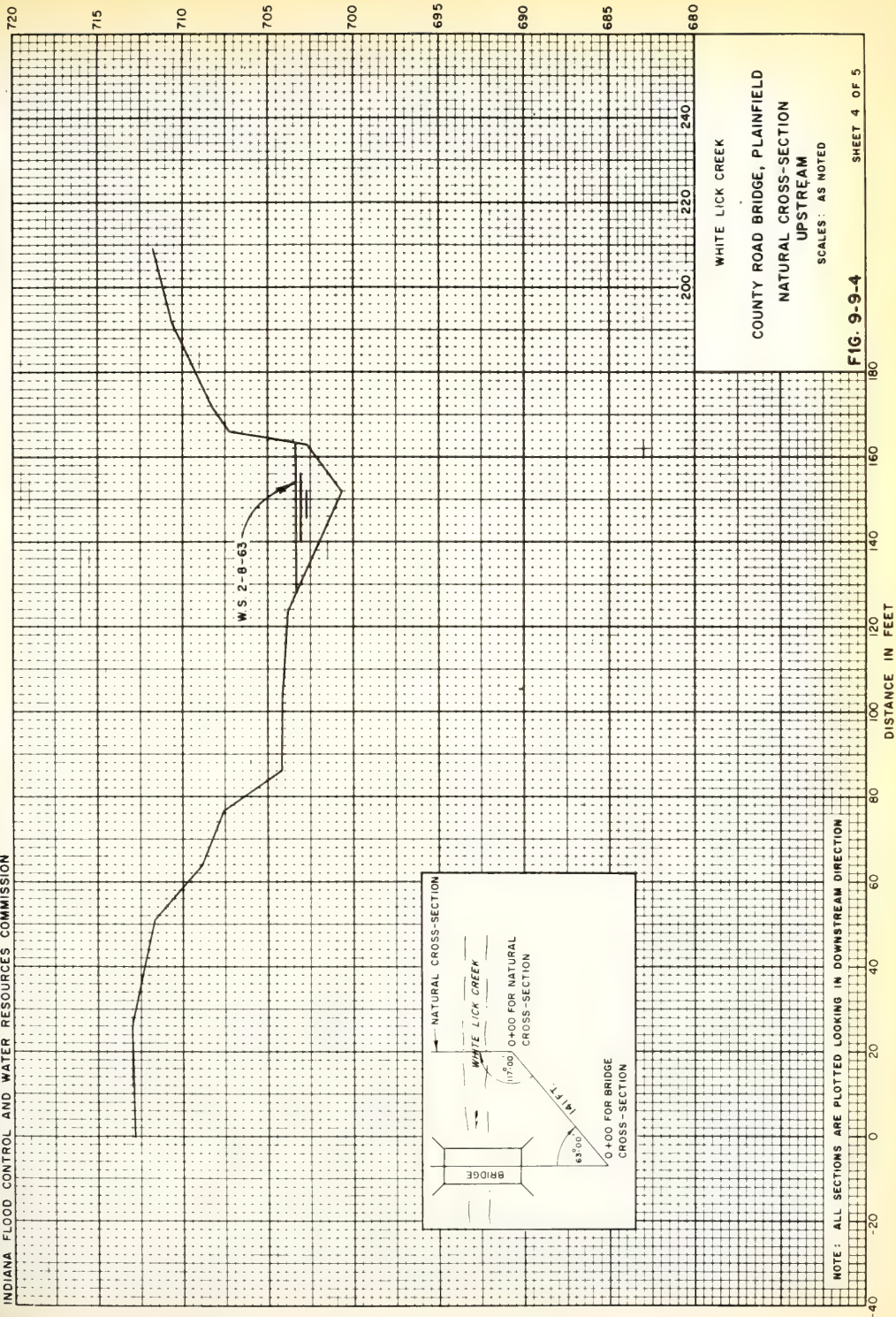
DOWNSTREAM SIDE

COUNTY ROAD BRIDGE, PLAINFIELD

WHITE LICK CREEK







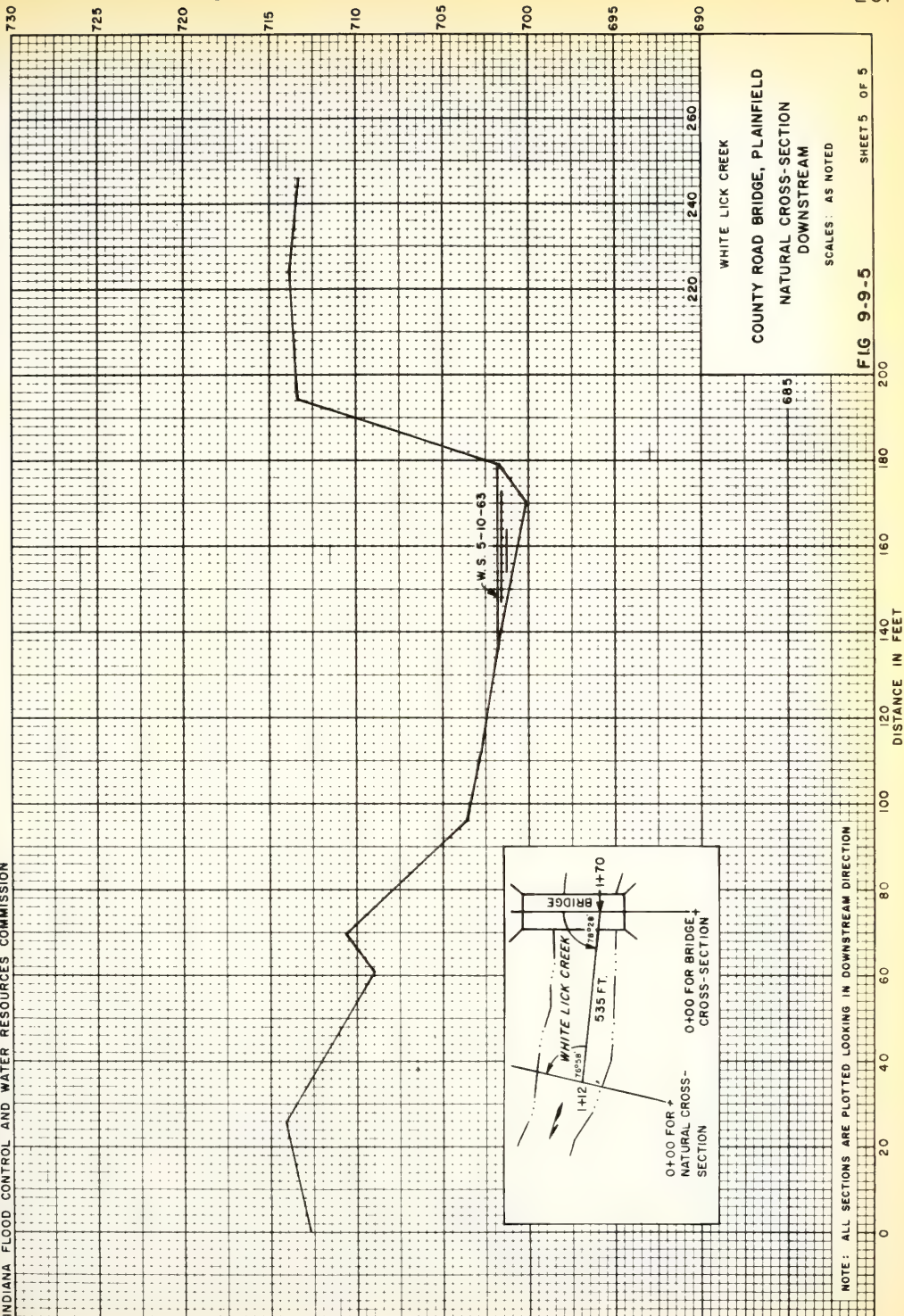
W.S. 2-B-63

WHITE LICK CREEK  
COUNTY ROAD BRIDGE, PLAINFIELD  
NATURAL CROSS-SECTION  
UPSTREAM  
SCALES: AS NOTED

FIG. 9-9-4  
SHEET 4 OF 5

NOTE: ALL SECTIONS ARE PLOTTED LOOKING IN DOWNSTREAM DIRECTION





NOTE: ALL SECTIONS ARE PLOTTED LOOKING IN DOWNSTREAM DIRECTION

FIG 9-9-5 SHEET 5 OF 5

DISTANCE IN FEET

695

200

180

160

140

120

100

80

60

40

20

0

690

695

700

705

710

715

720

725

730

735

740

745

750

755

760

765

770

775

780

785

790

795

800

805

810

815

820

825

830

835

840

845

850

855

860

865

870

875

880

885

890

895

900

905

910

915

920

925

930

935

940

945

950

955

960

965

970

975

980

985

990

995

1000

1005

1010

1015

1020

1025

1030

1035

1040

1045

1050

1055

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1065

1070

1075

1080

1085

1090

1095

1100

1105

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1115

1120

1125

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1140

1145

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1170

1175

1180

1185

1190

1195

1200

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1925

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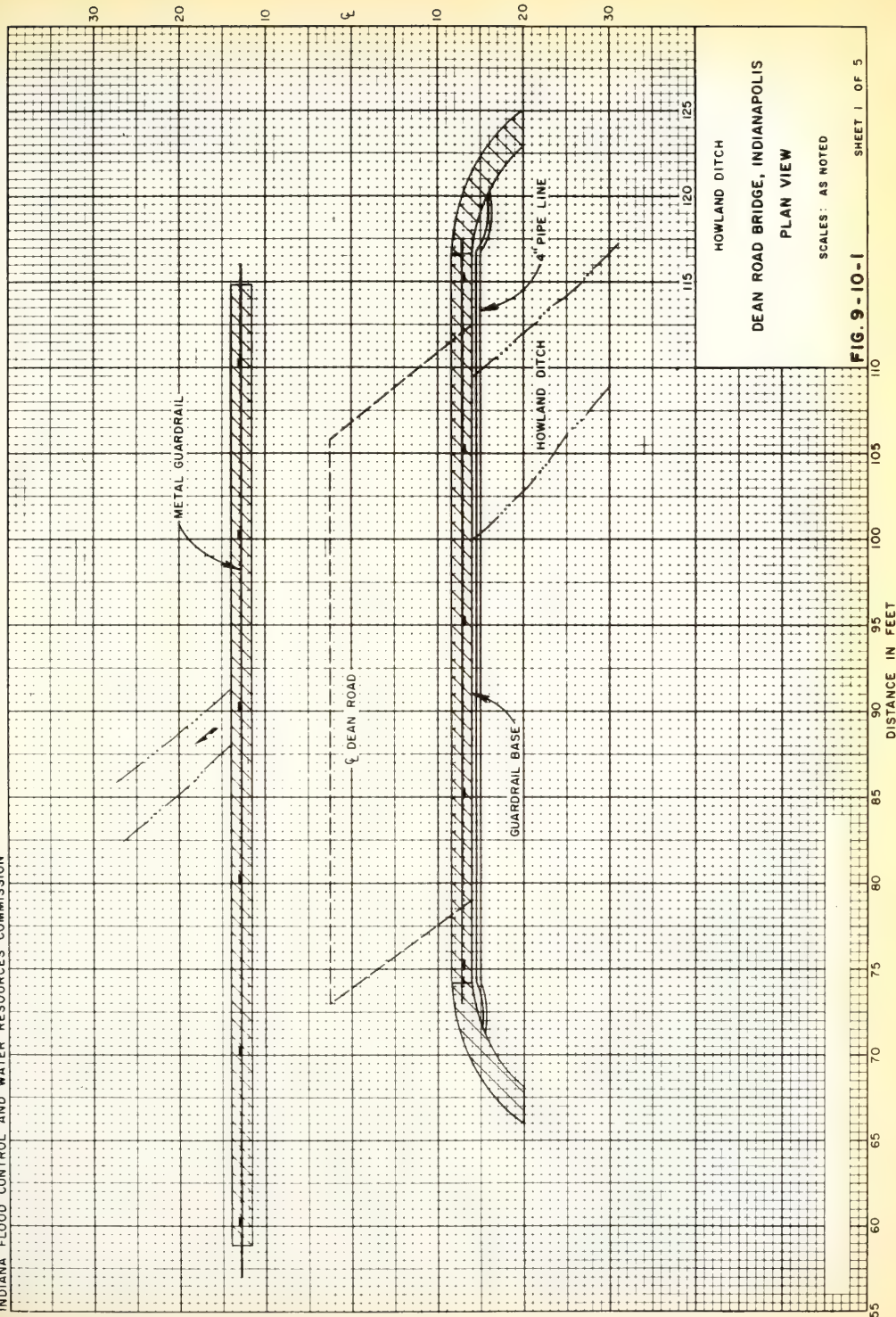
2035

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2045







HOWLAND DITCH

DEAN ROAD BRIDGE, INDIANAPOLIS

PLAN VIEW

SCALES: AS NOTED

FIG. 9-10-1

SHEET 1 OF 5

DISTANCE IN FEET



METAL GUARDRAIL

CROWN OF ROAD

CONCRETE BRIDGE

CONCRETE WINGWALL

NO. WS 2-12-63

4" PIPE LINE

GROUND

HOWLAND DITCH

DEAN ROAD BRIDGE, INDIANAPOLIS  
UPSTREAM FACE

SCALES AS NOTED

NOTE: ALL SECTIONS ARE PLOTTED LOOKING IN DOWNSTREAM DIRECTION

FIG. 9-10-2

SHEET 2 OF 5

115

110

105

100

95

90

85

80

75

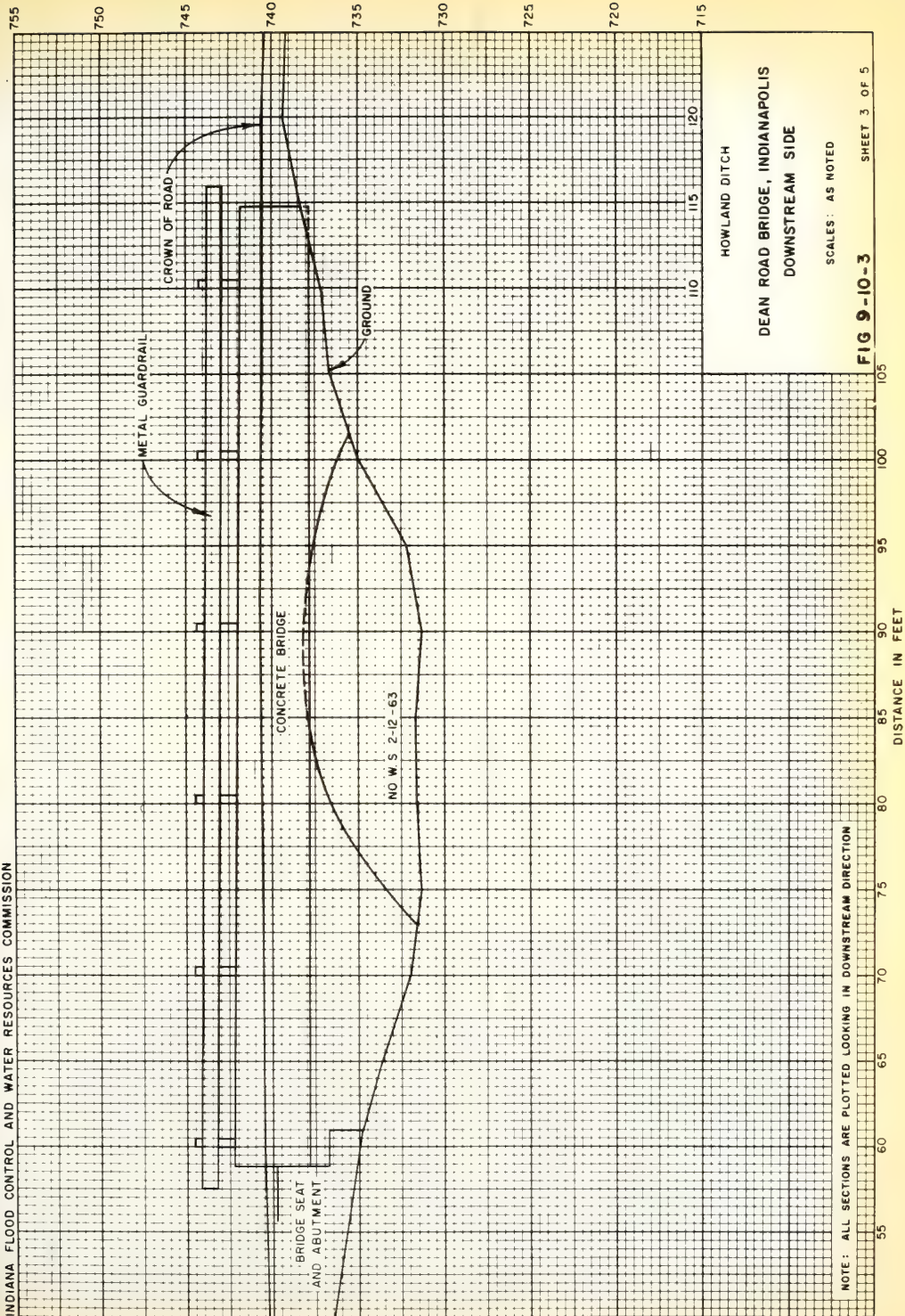
70

65

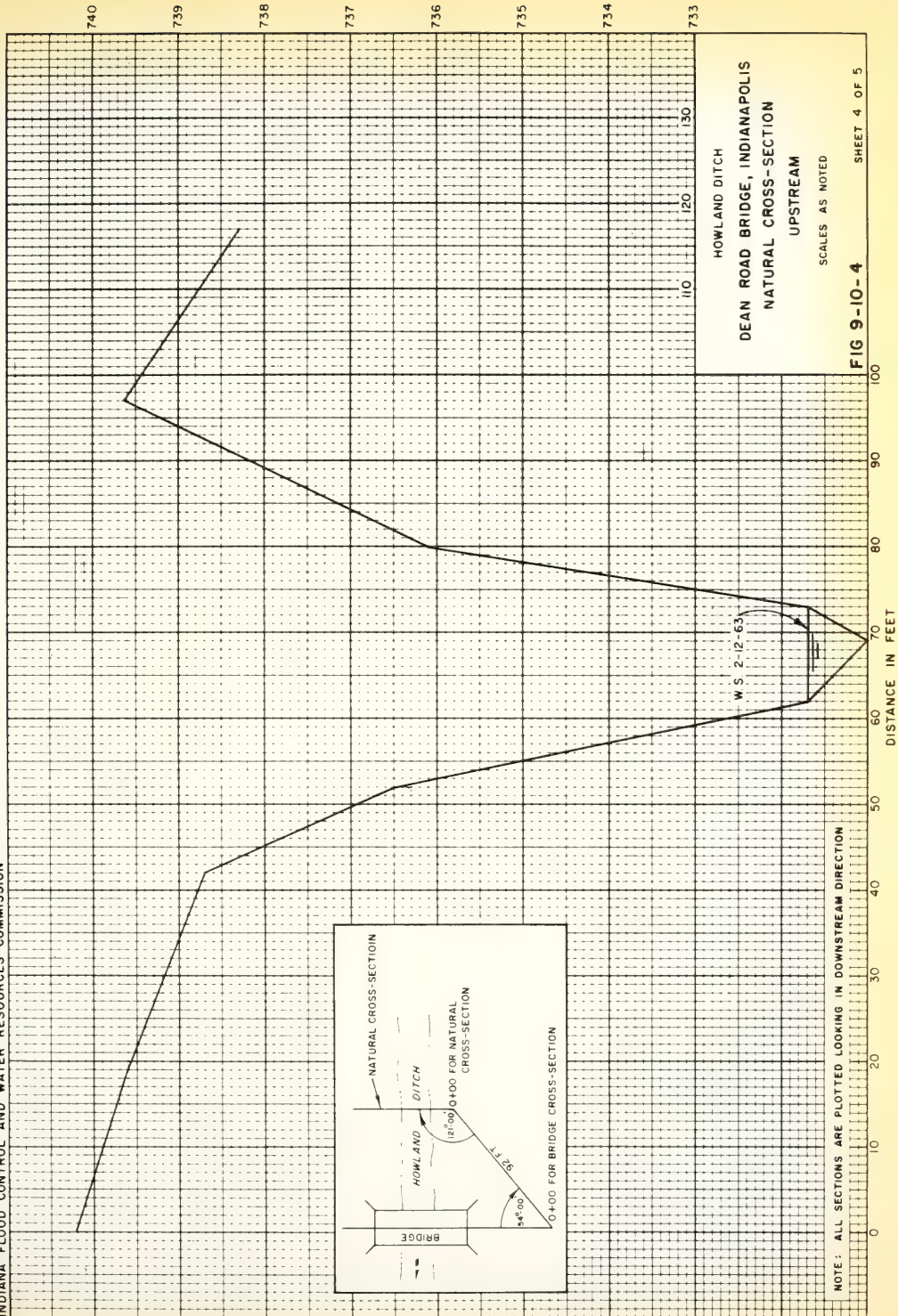
DISTANCE IN FEET











HOWLAND DITCH  
DEAN ROAD BRIDGE, INDIANAPOLIS  
NATURAL CROSS-SECTION  
UPSTREAM  
SCALES AS NOTED

FIG 9-10-4

SHEET 4 OF 5

DISTANCE IN FEET

NOTE: ALL SECTIONS ARE PLOTTED LOOKING IN DOWNSTREAM DIRECTION

10+00 FOR BRIDGE CROSS-SECTION

12+00 FOR NATURAL CROSS-SECTION

HOWLAND DITCH

NATURAL CROSS-SECTION

DITCH

BRIDGE

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HOWLAND DITCH

NATURAL CROSS-SECTION

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12+00 FOR NATURAL CROSS-SECTION

10+00 FOR BRIDGE CROSS-SECTION

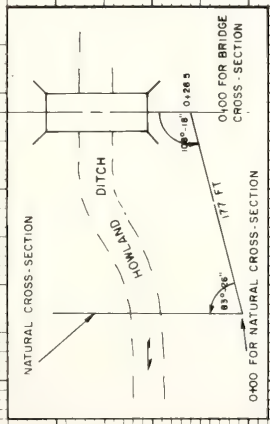
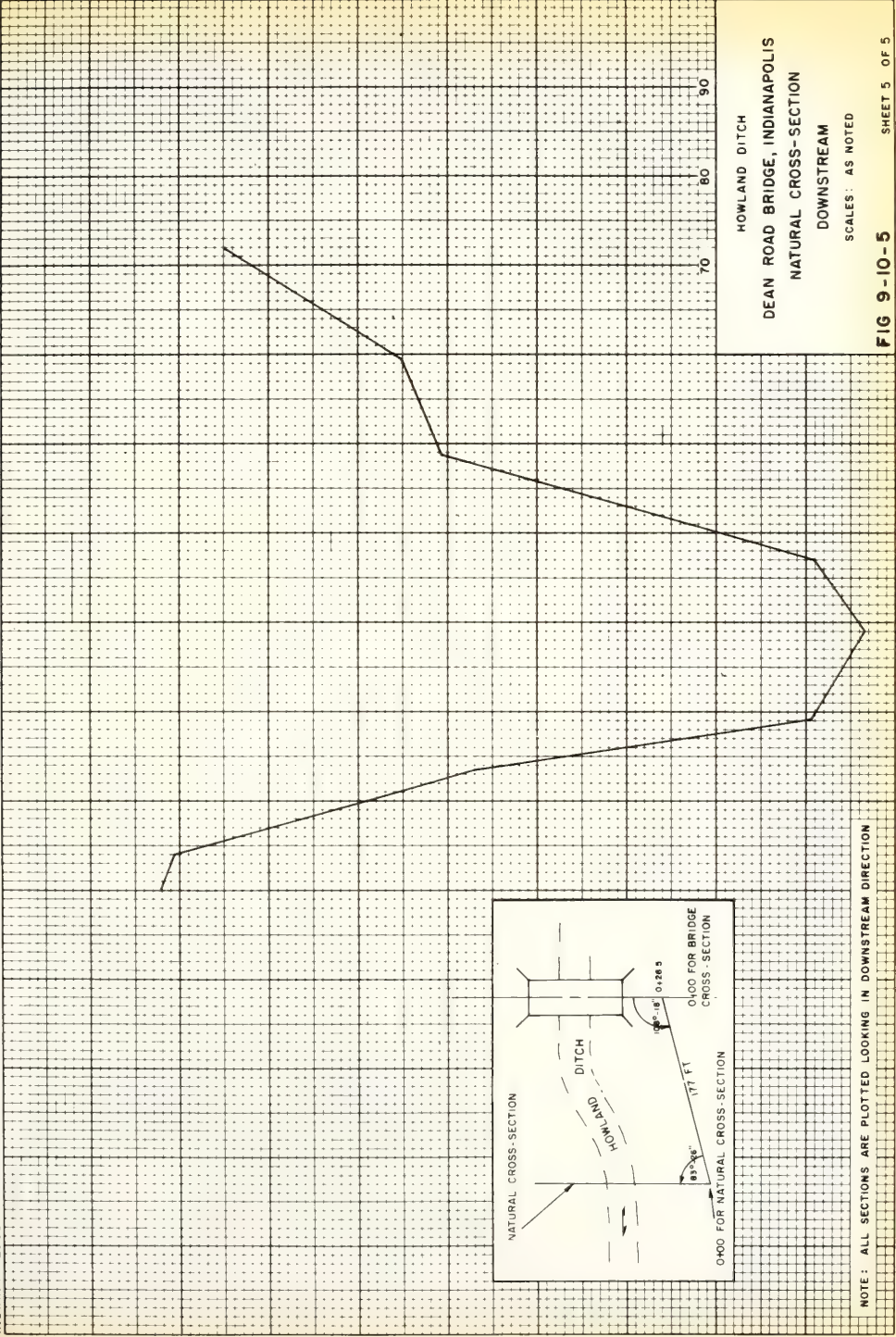
HOWLAND DITCH

NATURAL CROSS-SECTION

DITCH







HOWLAND DITCH  
DEAN ROAD BRIDGE, INDIANAPOLIS  
NATURAL CROSS-SECTION  
DOWNSTREAM  
SCALES: AS NOTED

FIG 9-10-5

NOTE: ALL SECTIONS ARE PLOTTED LOOKING IN DOWNSTREAM DIRECTION

DISTANCE IN FEET



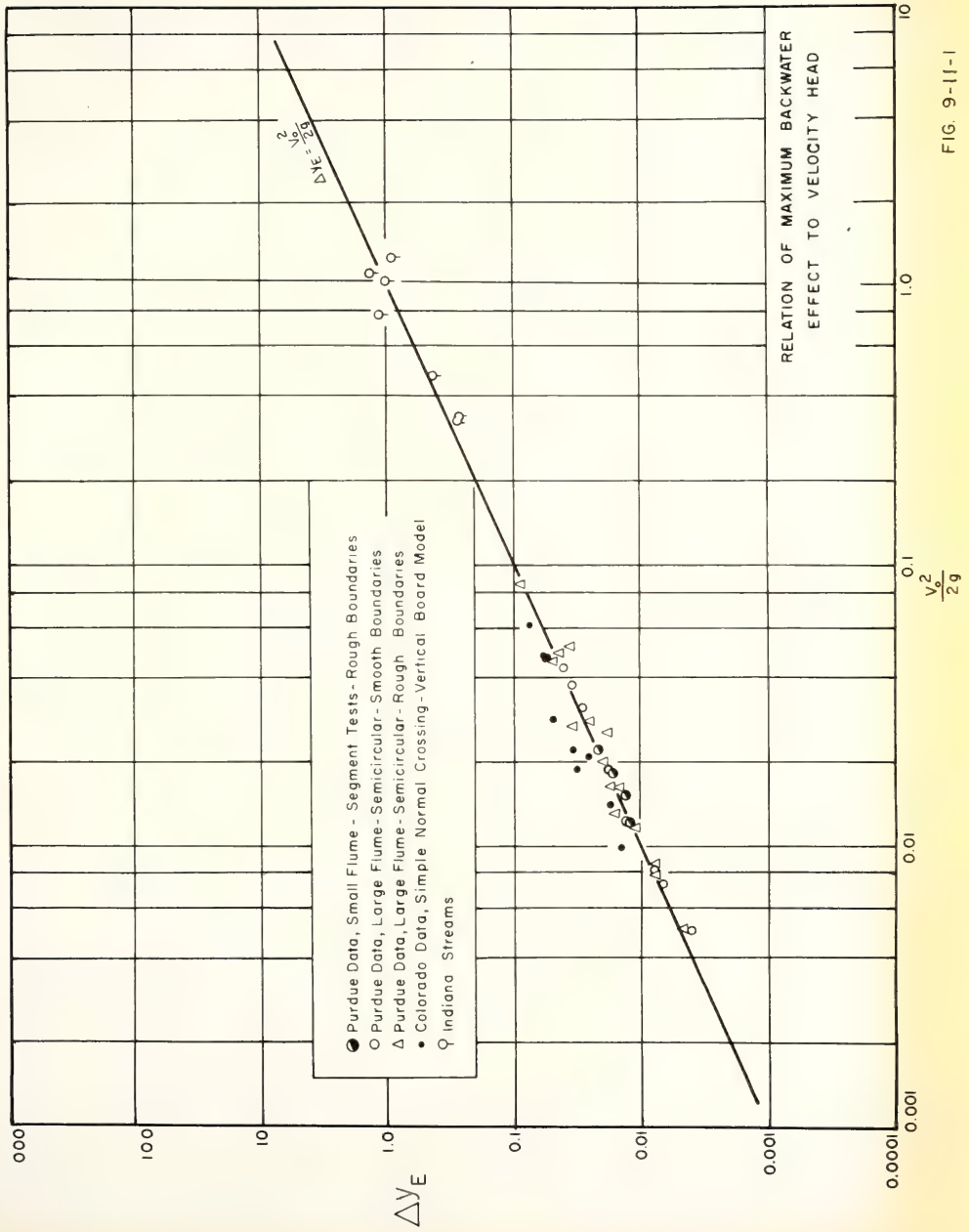


FIG. 9-11-1



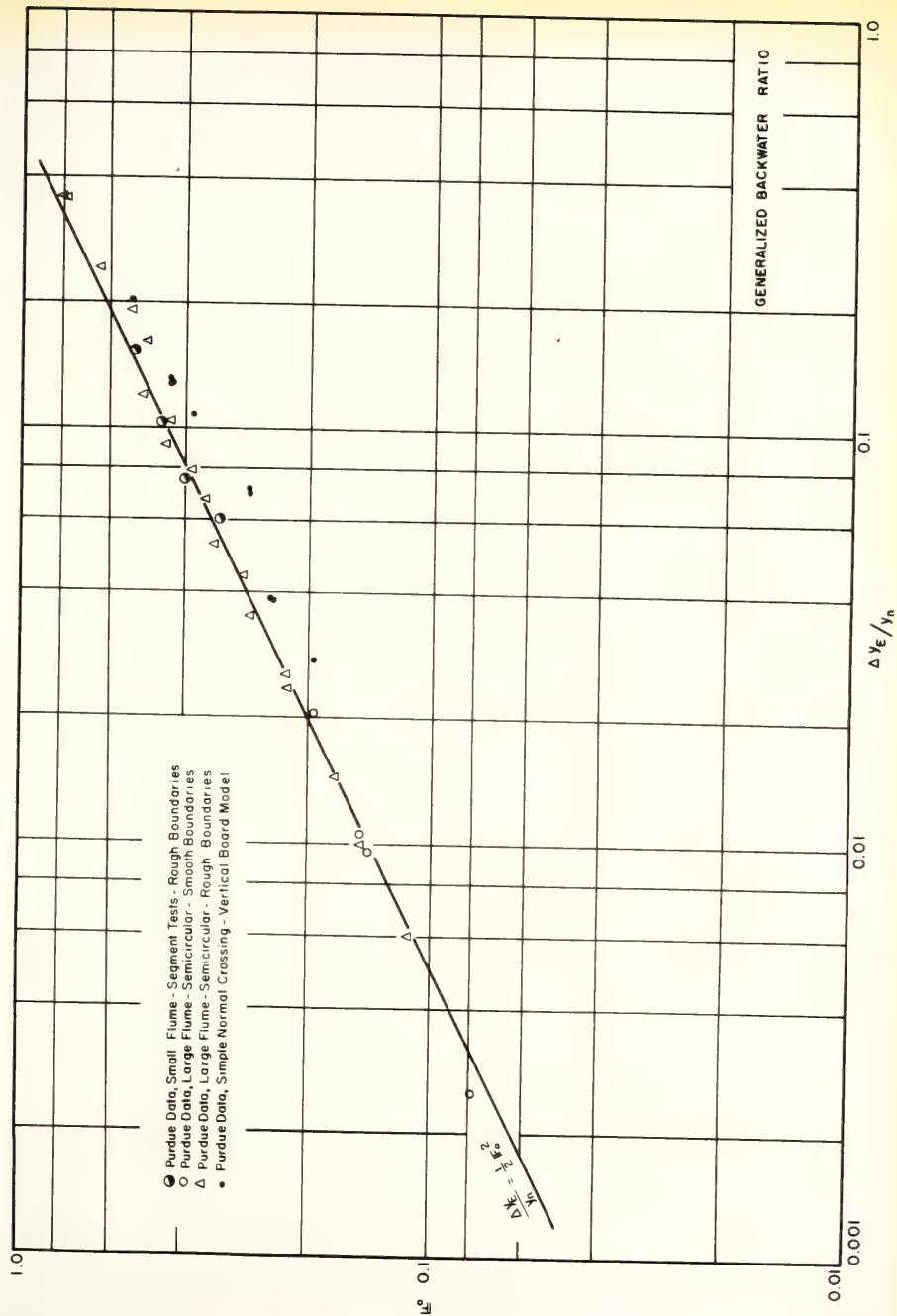


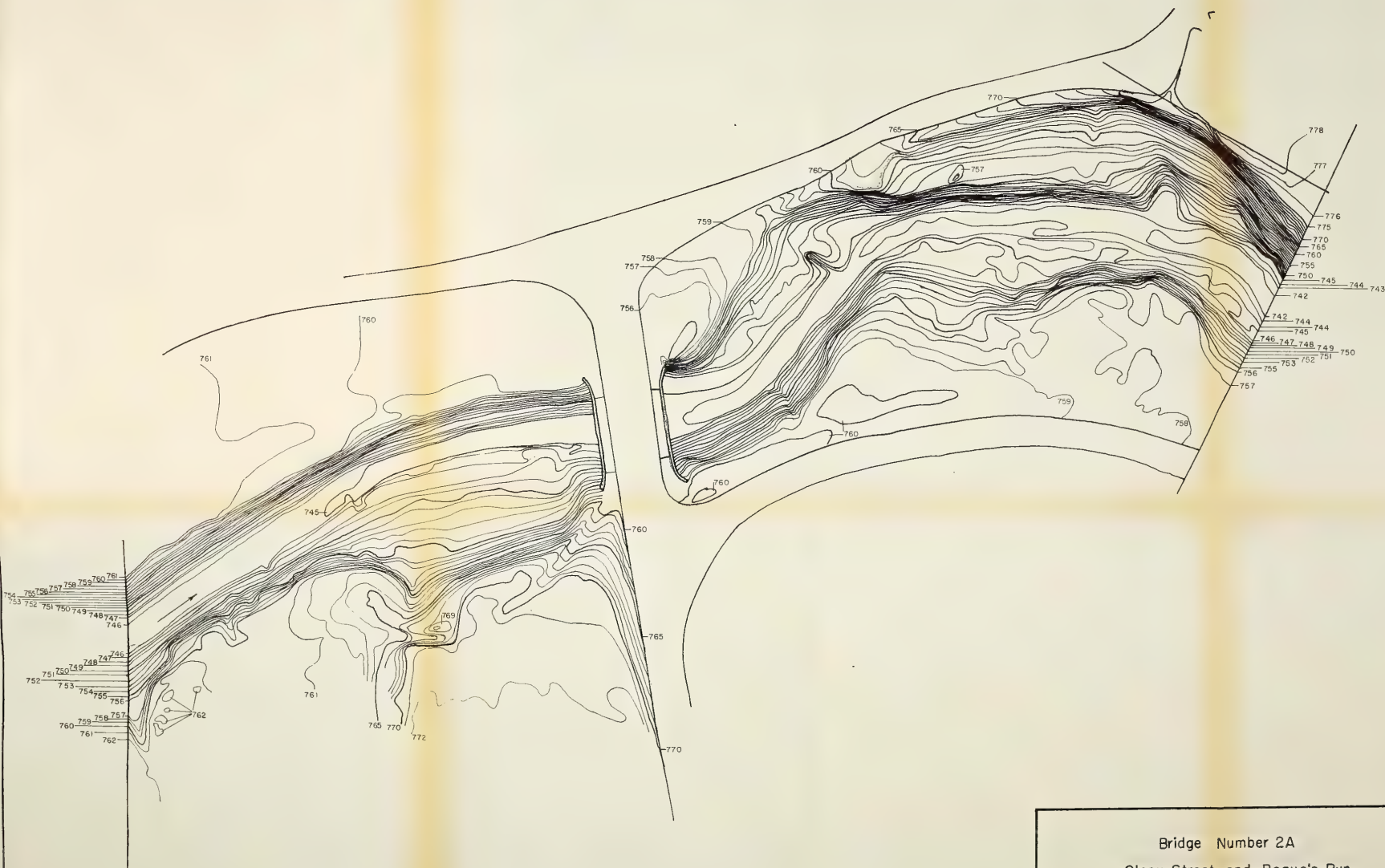
FIG. 9-11-2











Bridge Number 2A

Olney Street and Pogue's Run

Aerial Photographs Numbers 48 (166-167)

Scale: one inch represents fifty feet

July 1963

FIG. 9-1-6



734

730

735





Bridge Number 2C

Pogue's Run to Jefferson

Aerial photographs 48 (170-1)

Scale: one inch represents 50 feet

July 1963









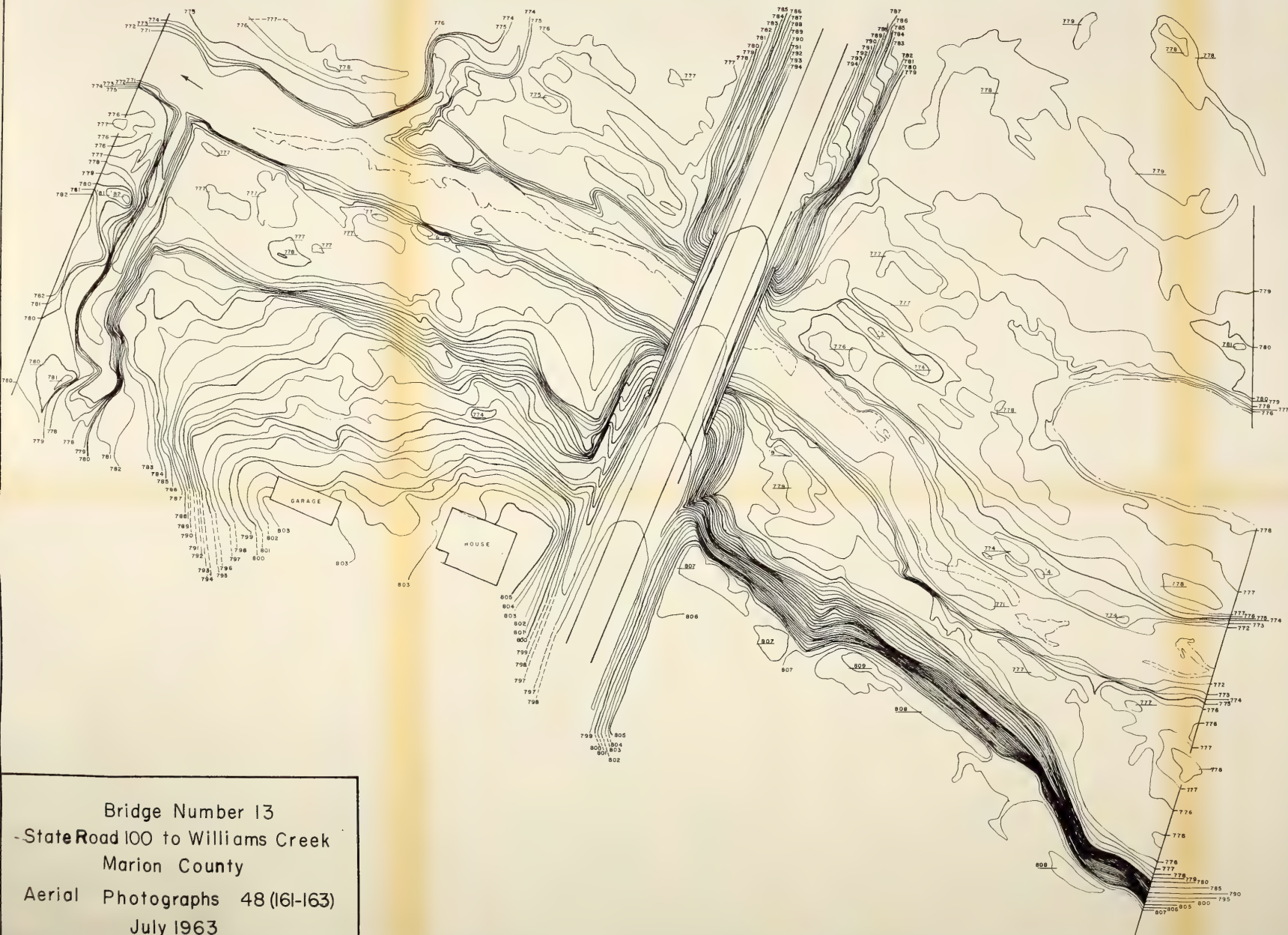


Bridge Number 8A  
South Belmont and Little Buck Creek  
Aerial Photographs 48 (157-B)  
Scale: one inch represents 50 feet  
July 1963









Bridge Number 13  
 -State Road 100 to Williams Creek  
 Marion County  
 Aerial Photographs 48 (I61-I63)  
 July 1963  
 FIG 9-5-6



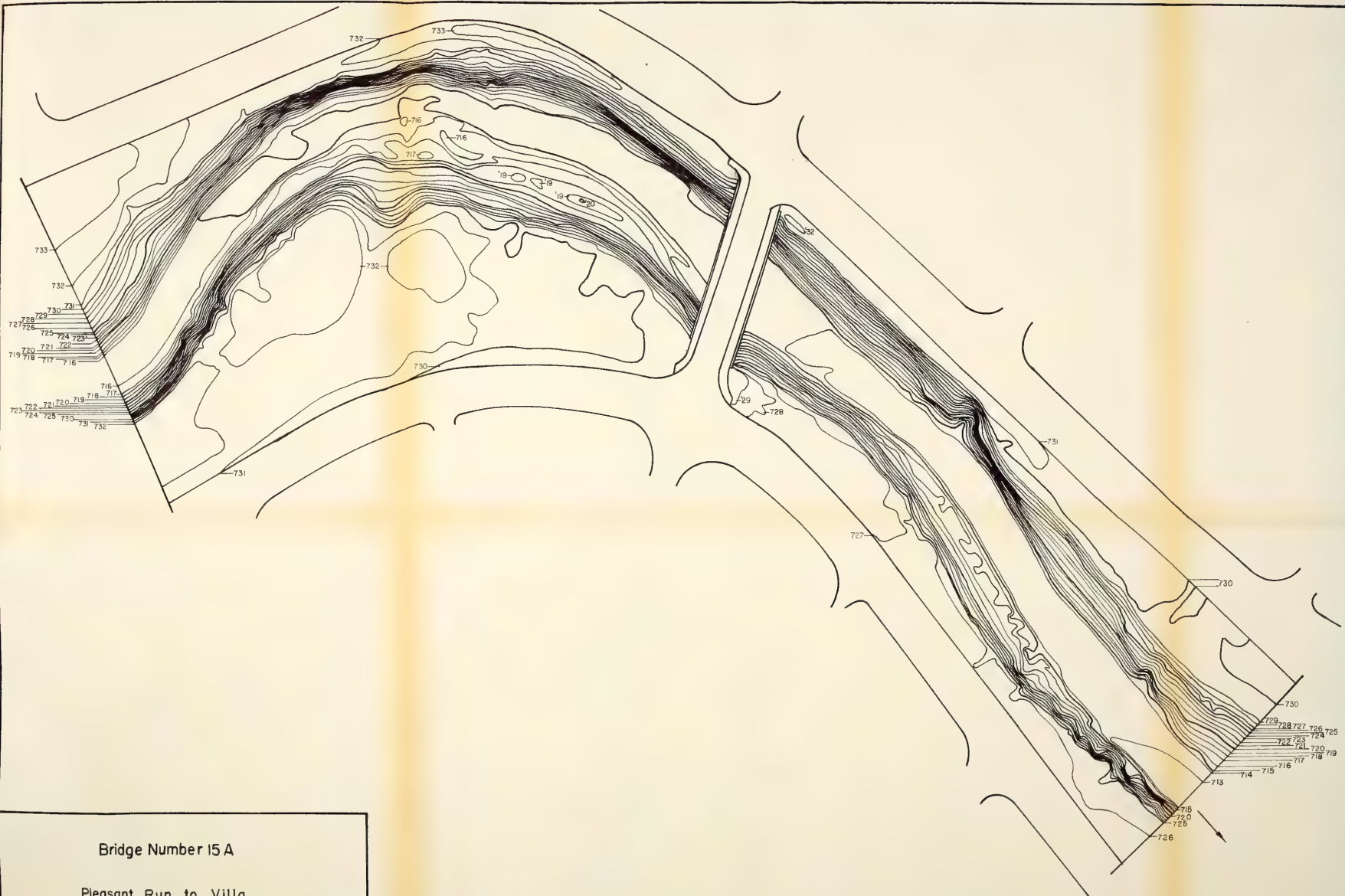
727

719

723







Bridge Number 15 A

Pleasant Run to Villa

Aerial Photographs 48 (172-3)  
Scale: one inch represents 50 feet

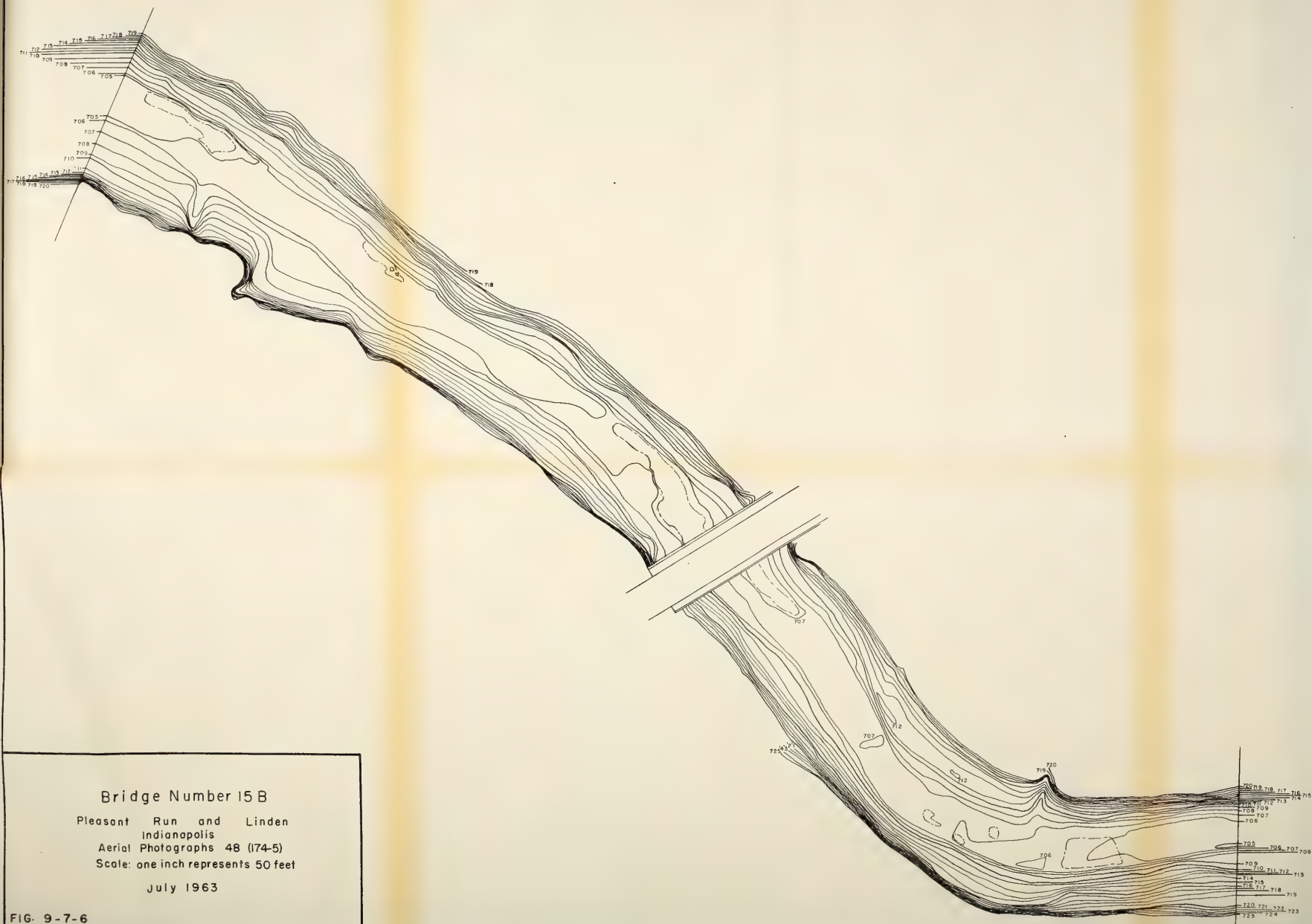
FIG. 9-6-6

July 1963

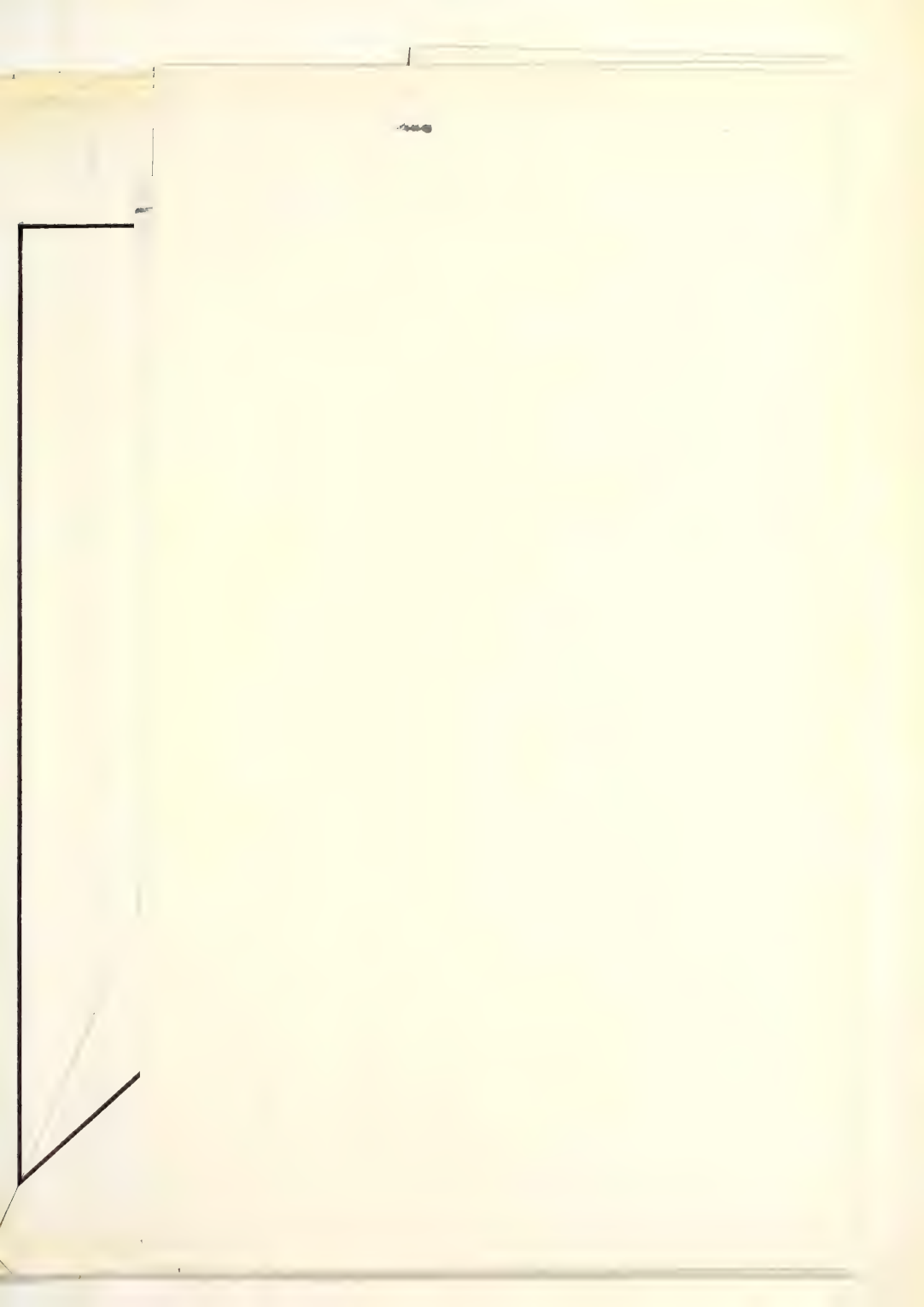


716  
717  
718

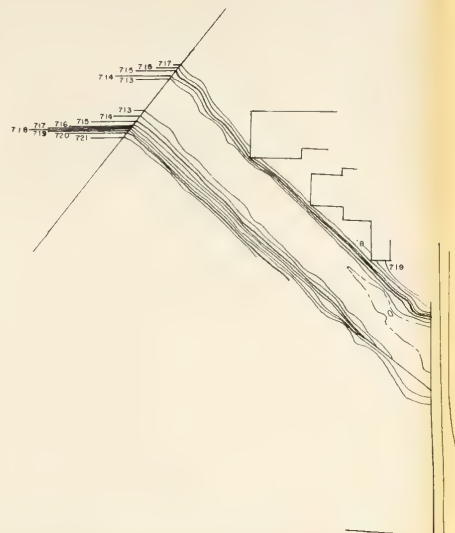












# Bridge Number 51

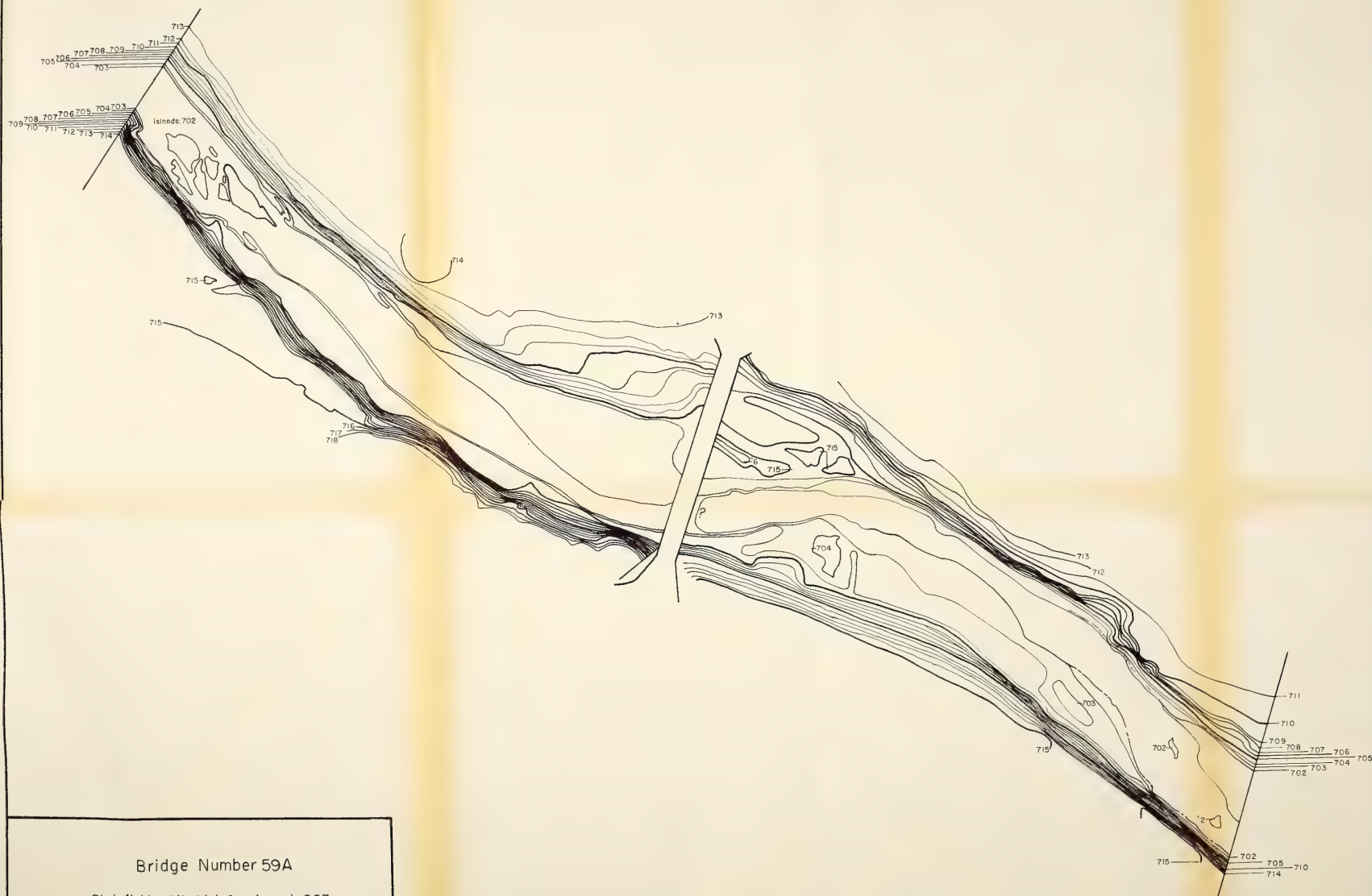
East Jefferson Street and Hurricane Creek  
Franklin, Indiana

Aerial Photographs 148 (155-156)

Scale: One inch represents 50 feet

709<sup>708</sup>  
710<sup>710</sup>





# Bridge Number 59A

Plainfield-White Lick Creek and 267

Aerial Photographs 48(159-60)

Scale: one inch represents 50 feet

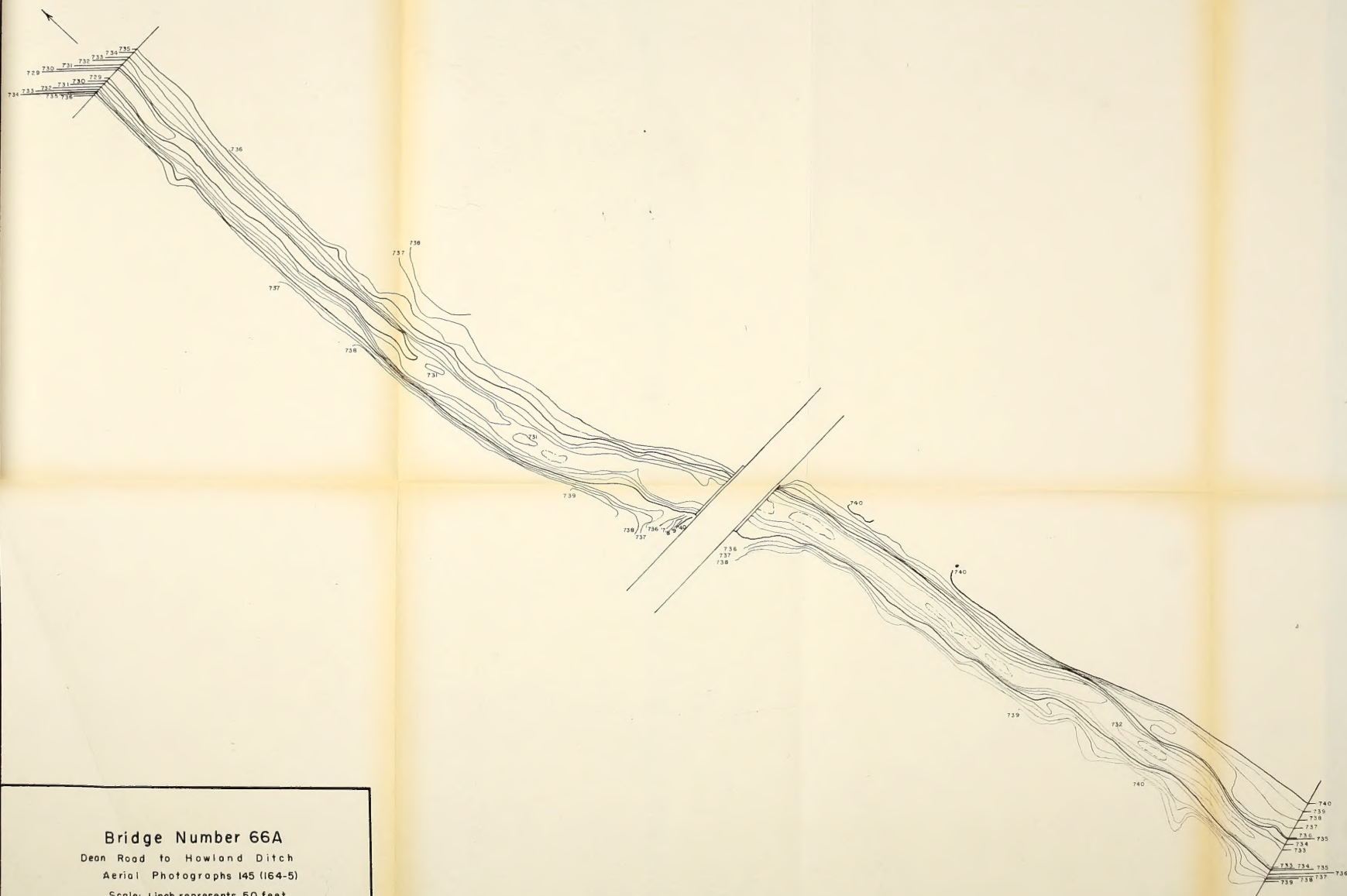
FIG 9-9-6

July 1963









# Bridge Number 66A

Dean Road to Howland Ditch

Aerial Photographs 145 (164-5)

Scale: 1 inch represents 50 feet

July 1963







